MANAGEMENT EDITION

THE Petroleum Engineer

Investment in Management
The Calculated Future
How to Get the Best Results from Research
The Perfect Price

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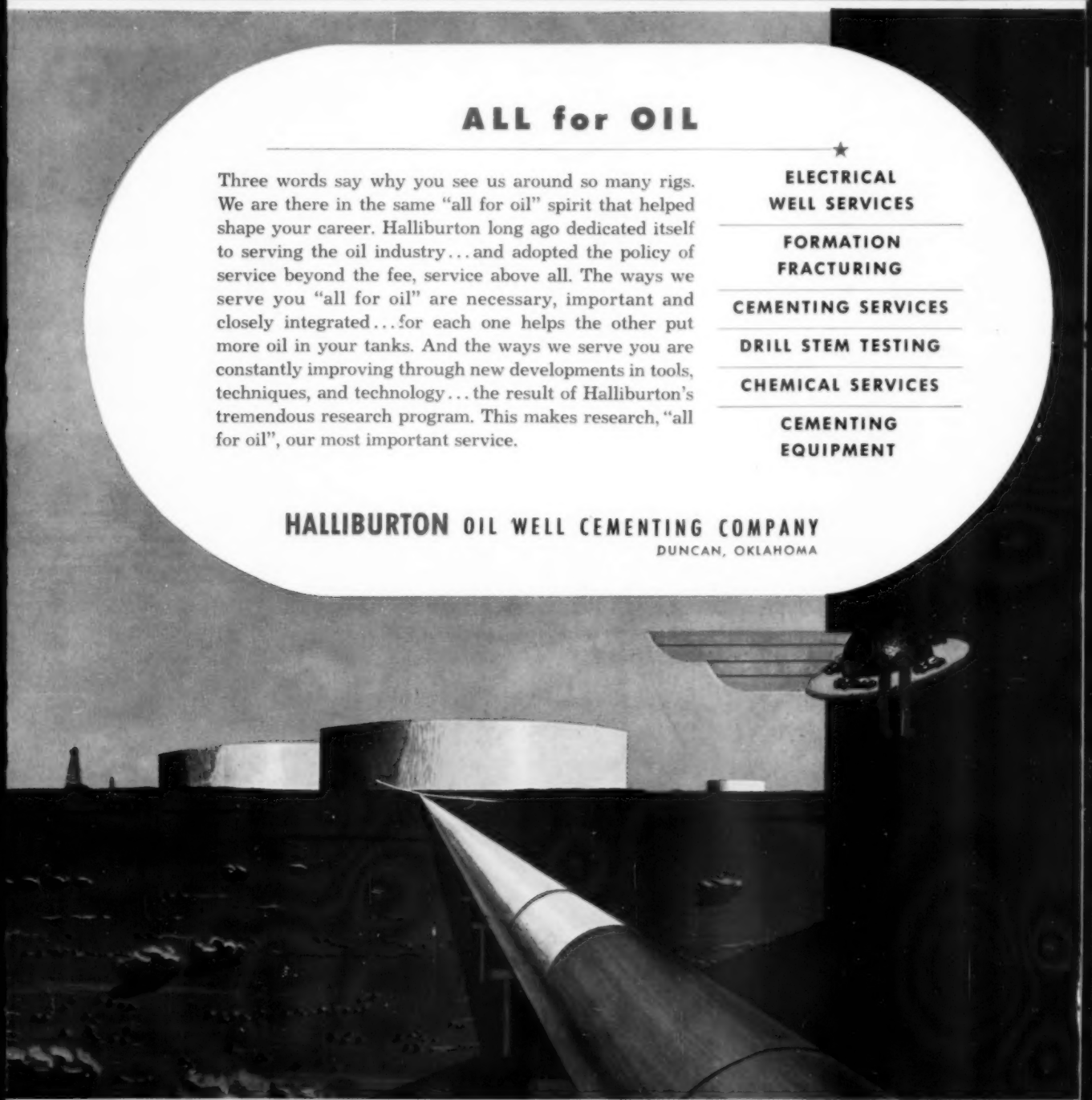

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Operation for leveling decline curves

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For example, a well originally completed in a dolomitic limestone formation in 1939 was given a standard acid treatment in 1950. Tests indicated 15 BOPD pumping. In 1952 Dowell engineers recommended Channeling Acid to increase production. The treatment consisted of 1500 gallons of Channeling Acid followed by 10,000 gallons of silicate control acid. Production increased to test 114 BOPD pumping. *More than three years later the well is still an excellent producer, pumping its allowable of 38* BOPD.

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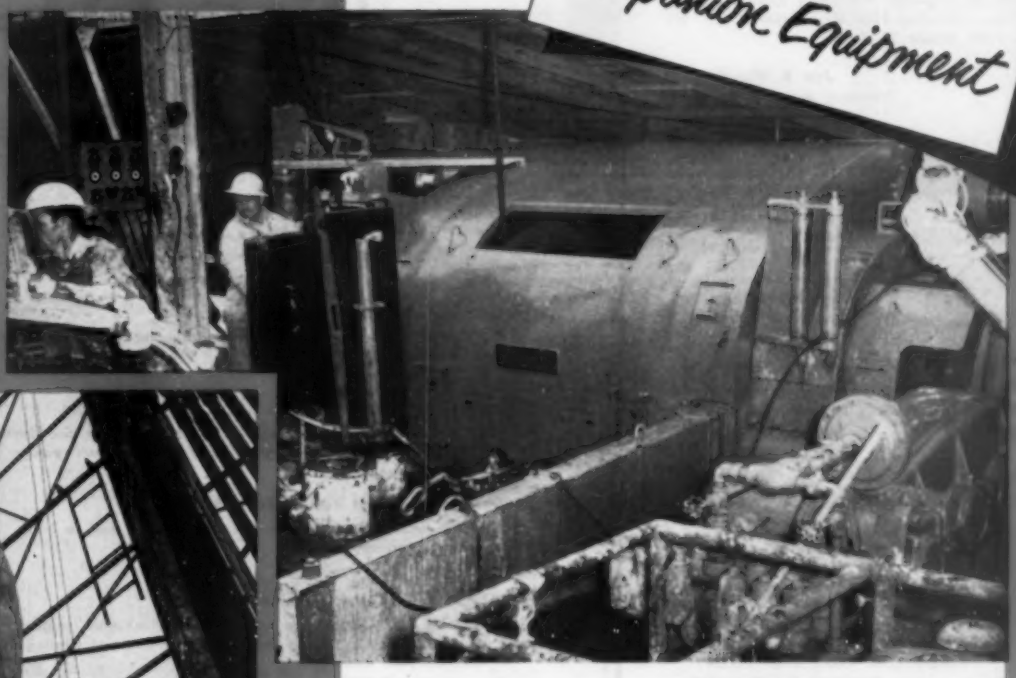

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An "Oilwell" No. 15 Automatic Drilling Control regulated the feed-off from the Draw Works and is shown at the extreme right. Two No. 818-P Slush Pumps were driven from the compound and furnished the mud for jet-bit drilling. A separate engine-driven No. 212-P Pump was used for mud mixing.

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tment in People

You hear estimates of capital expenditures for 1956 on every side. The Petroleum Engineer (January, 1956) predicted a total of $6.7 billion would be spent by the United States oil and gas industry alone (excluding gas public utilities).

The most important investment a company makes, however, is in people. Although you won't find them listed under these new investments, expenditures for the education and training and for general improvement in efficiency and health of people are also investments.

Investment in education for people has grown by leaps and bounds in recent years. Virtually every company of any size has a program of scholarships or school endowments or both. Every firm has some kind of training for employees that requires investment of effort and time and money to teach people how to work in the petroleum industry with benefit to them and to the industry.

Jersey Standard and affiliates have set up the Esso Education Foundation, which this year granted $1,067,900 to privately supported colleges and universities. Shell branched out into scholarships for high school teachers of science, engineering and mathematics as an investment in future scientists.

In this issue is an article about Cities Service's program to train executives called "Investment in Management." Nearly every company tries to provide for future executives by preparations of some kind. Sometimes the investment takes the form of sending employees to business seminars at schools and universities. Sometimes experienced top and middle management of the company take on the training.

Investment in people is a capital asset, too, and it is rising along with investment in machinery and equipment, which is at it should be. If people should fall behind, no amount of capital expenditures for plants and facilities would help our economy.

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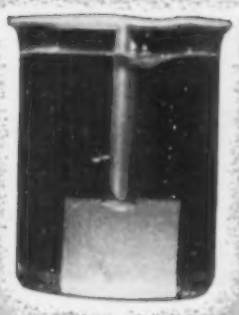

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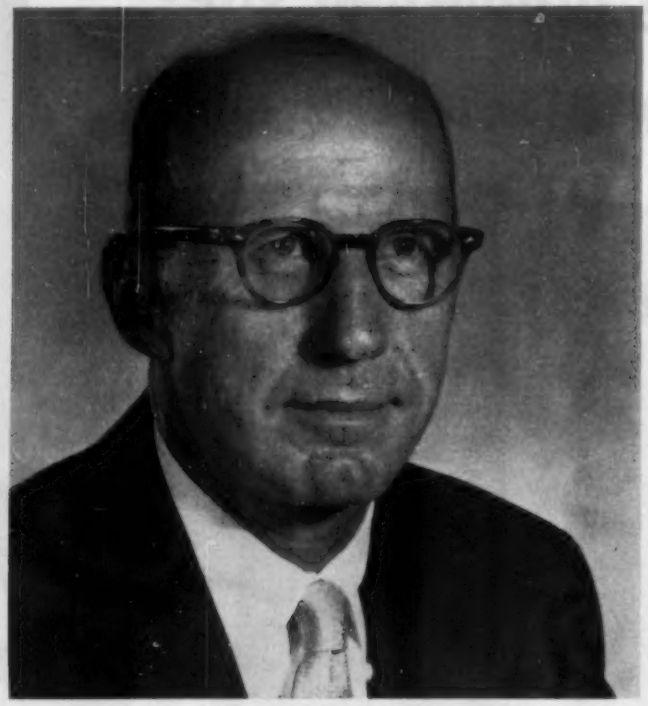


JOSEPH L. SEGER
Executive Vice President
Carter Oil Company

A happy blending of management talent, broad knowledge of the producing and pipe line business, considerable diplomatic skill, a firm grasp of the importance of the human element in business dealings —

Such a composite, wrapped into an energetic and enthusiastic package is Joseph L. Seger, Tulsa, Oklahoma, executive vice president of The Carter Oil Company.

Joe Seger thrives on being busy.

Every day, decisions in large numbers flow from his desk. A casual, courteous firmness is his stock in trade as he helps direct a large oil company with 3000 employees handling work in 26 states and engaged in the varied duties of exploration, production, manufacturing, marketing and petroleum research.

Seger was born in Lebanon, Illinois, and completed his grammar and high school work in Tulsa.

Back to his native state, he spent four years at the University of Illinois at Urbana, earning a Bachelor of Science degree in commerce in 1927. During summers, he was employed in a Tulsa bank. Continuing his education at Yale University, Seger received his law degree in 1929 and entered private practice in Tulsa the same year.

His shingle had been out four years when he joined the legal staff of The Carter Oil Company in 1933. He was elected secretary of Carter in 1944 and in the intervening years had played a key role in notable events marking Carter's progress. He was instrumental in the successful organization of the Elk Basin unit project and handled legal aspects of some of Carter's largest acquisitions of new properties by purchase.

To pin point the calendar box score of Seger's oil career, he transferred to Interstate Oil Pipe Line Company in June of 1946 and six months later was made a vice president and director of the company. Later he was made executive vice president, and he succeeded to the Interstate presidency in July, 1951.

That same year, he moved to Shreveport, Louisiana, and immediately assumed active roles in community and civic projects. He became a director and vice president of the Shreveport Community Fund, chairmaned a special gifts committee for a large hospital finance campaign there and served as a trustee of the Public Affairs Research Council of Louisiana. Industry affairs likewise received the benefit of his talents, and he served as director of the Transportation Association of America and chairman of The Committee for Pipe Line Companies.

In June of 1954, Seger was elected a vice president and director of The Carter Oil Company and returned to his old stand in Tulsa. At the time, he was also serving as president of the newly organized Yellowstone Pipe Line Company, operating in the Northwest. He still serves as a Yellowstone director. In September, 1954, he was made executive vice president of Carter.

Instead of slowing the pace, his 22 years in the petroleum industry seem only to have stepped up the tempo with which he tackles company, industry and community problems.

Currently, he is a director of the Tulsa Chamber of Commerce and a co-chairman of the executives division of the 1955 Tulsa Community Chest-Red Cross campaign.

Earlier years found him pursuing tennis as a "keeping fit" hobby, but recently he has undertaken less strenuous recreational sideline activities such as sailing at Lake Gibson near Tulsa. He is aided in his sailing ventures by Mrs. Seger and three children — Linda, 19, Christian, 16, and Mary Katherine, 13.

A tipoff to his constant concern with the human element in business transactions and business life came in a recent visit with company supervisors. Speaking informally to the "bosses" of a large number of men and women, he remarked: "We are very careful about the temperature of the bearings on our pumps and our engines, but are we concerned enough about the mental and spiritual temperature of our employees —the people who make up our company?"

He lives this philosophy in his daily work. Decisions concerning moneys and plants and iron and steel are judiciously tempered with consideration of the effects on personnel.

Without sacrificing efficiency, Carter's executive vice president takes time to say or pencil a "Thanks" or a "Fine" or a "Good Job" to those with whom he works. It's no wonder his calm yet dynamic enthusiasm automatically is imparted to those with whom he works.

"THE NEW NO. **583** IS THE ANSWER TO A PIPELAYER'S DREAM WHEN IT COMES TO CRADLING **BIG INCH**"

T. E. Davis, Superintendent
Williams Brothers Company

ONE of the first orders for the all-new CAT* No. 583 Pipelayer came from Williams Brothers Company, Tulsa, Oklahoma. A unit was put to work immediately in Virginia on a section of the 30-inch gas pipeline being built from Texas to New York for Transcontinental Gas Pipeline Corp. of Houston, Texas.

After watching the No. 583 at work beside other Caterpillar-built machines, Superintendent T. E. Davis commented:

"I've been 26 years with Williams Brothers in pipeline work using Caterpillar-built equipment. In my opinion, there is no better equipment made. And the new No. 583 is the answer to a pipelayer's dream when it comes to cradling big inch."

Mr. Davis particularly liked the ground clearance and counterweights on the new unit—the first pipelayer which is *all pipelayer and not a tractor attachment*.

The No. 583 has good stability and balance to obtain the best ground pressures on each track. In addition the counterweights retract well over track to give maximum right-of-way clearance. And they stay put in retracted position without hydraulic pressure.

The No. 583, *with a lifting capacity of 130,000 pounds*, is the most efficient pipelayer in history. Caterpillar engineers worked closely with pipeline people in designing it, so it answers the problems *you* wanted licked. No detail has been overlooked.

It has so many new developments, it must be seen personally to be appreciated. A few of these features are: the live drive which supplies steady power to the boom and load lines independent of the flywheel clutch, torque converter drive which permits crawl speeds necessary for lowering in, 21-inch ground clearance and others. So see the No. 583 soon. Your Caterpillar Dealer will show you how the *first unit-built* pipelayer can boost profits on your jobs.

Caterpillar Tractor Co., Peoria, Illinois, U. S. A.

CATERPILLAR*

*Caterpillar and Cat are Registered Trademarks of Caterpillar Tractor Co.

MODERN HEAVY-DUTY PIPELAYING EQUIPMENT

THE PERFECT PRICE

Benjamin F. Fairless

WHAT DETERMINES the price of a ton of steel? Who sets it? Just what is the policy of United States Steel as to prices?

Along with other successful American industries, we in the steel business learned a long time ago that the following economic principle is true and sound: Each manufacturer must learn how to produce and sell his products as efficiently and cheaply as his competitors. If he doesn't, he will soon find himself without customers because of the competitive struggle for markets in a free economy. Any successful business must necessarily conform to that fact of the market place if it is to prosper and fulfill its obligations to its employees, its owners and its customers. A by-product of this competition among producers is the best possible product and service at the lowest possible price.

Actually, I could state—simply and truly—that in the long run it is the customers who primarily set the price of steel as they set the price of everything else, and that—again in the long run—the opinions of government officials, the general public, the owners and even the management have astonishingly little to do with it.

BUT BEFORE explaining a few of the most important factors that play a part in determining the final market price of steel, I must mention one theory of pricing which, most definitely, we do not use. I refer to the cost-plus theory. I mention it because many people seem to be under the impression that manufacturers set the prices on their products by the process of adding an arbitrarily fixed mark-up to all costs. No business can be run successfully in that way as long as it has competitors in a free market.

It is true enough that a company must recover all its costs—plus a profit—if it is to stay in business. And, admittedly, our company does aim to recover all its costs, plus a profit, from the sales of its products. But we run into all sorts of problems and complications along the rugged path to that desired goal.

For example: It seems that almost every time U.S. Steel raises its prices, we are expected to justify the price increase to everybody except the people who are asked to pay it—our customers. Fortunately, they neither need nor want a long story; our customers know at first glance whether the price is right or not. And they render their combined verdict without any political speeches or vote-getting clichés. We are acutely aware of the fact that they can turn to any one of our numerous and eager competitors, or look for a substitute, or cut down on inventory, or even cut back on production. Whether the customer's verdict on our prices is for us or against us, we still believe it is the right verdict as it is delivered by a free person using his own money in a free market.

*Mr. Fairless is Chairman of the Executive Advisory Committee, United States Steel Corporation, and President, American Iron & Steel Institute.

But the matter of price does not rest there. Government officials, union leaders, the public—as represented by certain newspaper columnists and radio commentators—always show a keen interest in the price of steel, and we are always willing to explain to any interested person how we arrive at the prices we hope to get for our products.

NATURALLY, any explanation about prices must dwell at length on costs, since they are the first factors we must consider in arriving at a price that we hope will stand up in a competitive market. The largest cost of all is, of course, wages and salaries—including pensions, social security, insurance and other benefits—paid to or for the employees of the company. The second largest cost is the products and services bought by the company. Next comes the cost of government, in the form of taxes.

Time and again in the past, we have explained these three largest costs in great detail to anyone who would listen. Doubtless we will explain them time and again in the future. When we point out the obvious fact that these costs must be covered in the price of our products, everyone usually understands and approves. But there are two generally unrecognized dangers in this approach. First, as I have already mentioned, it frequently misleads the unwary into the fallacious belief that industry can and does operate exclusively on a cost-plus basis. This, of course, isn't even remotely correct. Second, when we begin listing our costs of doing business, we run into the awkward fact that some people claim that many of the things we must pay for aren't costs at all!

For example, you might think that everyone would agree that depreciation—that is, the using up of machinery during the process of production—is a cost of doing business. But the taxing policy long followed by Congress does not realistically recognize that fact. Under present circumstances, its rules on regular depreciation permit us to list as a cost only a fraction of the purchase price of an equivalent new machine which is to replace a worn-out or obsolete machine. Apparently the government still refuses to acknowledge the fact that its inflationary policies have caused prices for new equipment to double and treble since the old equipment was bought some twenty years or more ago. It permits us to recover approximately the same number of dollars originally invested, but it forbids us to recover the same amount of purchasing power.

The price of steel is also heavily influenced by another vital factor which is not generally given the consideration it deserves. I refer to growth and expansion and modernization. Everyone will agree that it costs money to modernize an old steel plant or to build a new one. But you can start an argument with almost anyone as to where that money is to come from. There are only three possible sources.

It must come from a realistic treatment of depreciation recovery which recognizes the reality of inflation; or it must come from the sale of stocks and bonds; or it must come from profits.

WE HAVE already examined the depreciation possibility—and found it wanting. Now let's take a brief look at the possibility of raising the needed capital by the sale of stocks.

Here we must face this unhappy and persistent fact: Over the years, the profits and dividends of U.S. Steel have just not been sufficiently large to permit it to attract needed capital funds from stock purchasers! Investors just won't buy ownership in our company in the form of stock at the price it now costs us to build the new plant and equipment. For example, take the Fairless Works—a fully integrated steel plant we recently built. Its cost to us was about $300 per ton of ingot capacity—or about $400 per ton of finished product.

Ownership in our plant and equipment and other assets can be purchased in the form of stock certificates on the open market. But the verdict of a free people in a free market who are using their own savings to buy stock is that (at the time of writing) they will pay only $79 for ownership of the facilities it would now cost us $300 and more to build!

While there is no doubt that our company can raise capital funds through the sale of common stock, we have found it more advantageous either to borrow the money and pay it back out of future earnings or to use a portion of current earnings. And we have followed both courses. Last year, for example, we borrowed 300 million dollars. But mostly we get this new capital for expansion and modernization by plowing back into the business about half of our earnings. Some of our owners aren't convinced that this is the best policy, and often we have been advised to meet rising costs (and to pay more equitable dividends) by simply adding a few more dollars to the price the customer must pay for steel.

Those who make that suggestion seem totally unaware that, in a free economy, competition for customers insures not only the best possible product but also the lowest possible price. Even after that, the final fact remains that the customer can't be forced to pay anything at all! In a free economy, the customer is still king.

So it is understandable why the one to whom we devote most of our thought and effort is the customer. Under normal conditions in a competitive market, the customer would laugh in our faces if we went to him with our problems and suggested that we do business on a straight cost-plus basis. If we did, he would probably tell us the old story of the three friends who met in wartime Washington and decided to have dinner together. When the check came, one man reached for it with this explanation: "Since I can deduct this for tax purposes as a business expense, it will actually cost me only about 20 per cent of the total." But the second man grabbed it from him and said: "Let me pay it since I'm a salesman on an expense account and it won't cost me anything at all." Then the third man grabbed the check from the second man and carried the day with this announcement: "I'm a manufacturer with a cost-plus contract from the government. If I pay this bill, I'll get my money back—plus 10 per cent!"

Our customer has problems of his own, and he's just not interested in hearing ours. All he is interested in hearing from us is our asking price for the steel he wants—delivered when and where he wants it. If he doesn't like our price or service, we lose a customer to our competitors. And the fact of the matter is that we do not enjoy losing customers.

SO WHEN we think about prices for our products, we must consider all of these problems I have listed. We naturally give much thought to the reaction of the general public since, understandably, they have considerable interest in the activities of such a basic industry as steel. And, admittedly, we have no choice but to take a look toward Washington and see what Congress is going to do about taxes, controls, investigations, inflation and other real political problems which all businessmen must consider today. Obviously we try to guess what the union leaders have up their sleeves for our next meeting. We also keep a close watch on the price, quality and service our competitors are offering. And since the stockholders own the business and can fire us if they wish, we do the best for them we can. Then we reach for our crystal ball and take a thoughtful look at both the domestic and foreign markets and the state of the world in general. After all those facts and figures and guesses have been digested, we finally ask ourselves this all-important question: Will the customer buy our products at the prices we have in mind?

For various reasons in the past, the answer to that question has sometimes been "no." And we have had no choice but to reduce the price to what the customer would pay under competitive conditions—even if it meant a loss to us, which it sometimes did.

In the free and competitive market which characterizes our economy—except, of course, when the government interferes—a price is perfect when the producer would rather have the money than the product, and when the consumer would rather have the product than the money. A perfect price is established when the seller and the buyer each improves his welfare by the trade. I am of the opinion that given a free and competitive market—with government confined to its proper role of protecting equally the life, liberty and property of its citizens—all prices for all products would be about as perfect as fallible human beings are capable of making them. ★ ★ ★

HIGHLIGHTS ★ ★ ★

Digest of News and Comment

Coordination of independent oil union bargaining got under way in January for mutual defense against the aggressive Oil, Chemical and Atomic Workers (AFL-CIO). Thirty independent unions met in a Baton Rouge, Louisiana, convention to work out preliminary bargaining plans for higher wages and increased fringe benefits for refinery, oil field, and distribution workers. The smaller groups are showing increased concern over OC&AW's movements into independent union strongholds.

★ ★ ★

Federal government has been lauded by W. W. Vaughey, retiring president of the Independent Producers Association of America. Speaking to Oklahoma Independent Petroleum Association members, Vaughey said the U. S. government took three important steps last year "toward a sound and more consistent" oil and gas policy. Favorable actions were listed as the report on energy supplies and resources policy by a special cabinet committee, congressional adoption of the defense amendment to the Trade Agreements Act, and house passage of the Harris natural gas bill.

★ ★ ★

Important leasing legislation will be up for consideration by the Senate Interior Committee early this year. Pending before the group are bills to require competitive bids on oil and gas leases on acquired public lands not within a known geologic structure. Others would grant states the mineral rights on public lands provided income derived would be used for public education.

★ ★ ★

California Crude Sales Company has been organized as a subsidiary of Standard of California. New international organization will market crude oil produced outside the U. S. and will centralize activities now carried on by several other companies in the California Standard group.

★ ★ ★

Atlantic Refining Company has tentatively agreed to buy oil, gas and pipe line properties of Houston Oil Company, whose directors recently voted to liquidate all assets. The 55-year old Houston Company, which employs 725 persons in Texas and Louisiana, was linked last year with merger talks involving Sinclair, Tennessee Gas Transmission, Sohio and the Belgian-owned Petrofina. Atlantic's acquisition of the southwestern holdings would help correct an imbalance between crude needs and refining capacity, which the company says has hampered earnings in recent years. Liquidation proceeds of Houston Oil are expected to amount to $224,654,265.

★ ★ ★

Market demand for crude oil in 1956 is expected to show a 3.9 per cent rise, including a 9.9 per cent decrease in total exports and a 4.5 per cent gain in domestic demand, according to Bureau of Mines forecasts. The expected increases are based on estimates of further gains in actual demand.

★ ★ ★

Liquefied petroleum gas sales in 1955 leaped to 6 billion barrels. The 17.2 per cent gain is the largest yearly increase in the history of the industry, according to Phillips Petroleum Company officials. Increased LPG use for weather conditioners in the home, as a motor fuel and chemical applications are expected to give butane and propane another "spectacular" year.

★ ★ ★

Depletion allowance for oil and gas income will probably go unbothered, at least for a while. Joint Congressional Committee on the Economic Report, which has conducted a study of proposed tax changes this year, made no recommendation either for changes or retention of the depletion allowance. Senator Douglas of Illinois submitted a supplemental report which would consider the allowance justified only for the "small operator not able to distribute drilling risks."

Sun Oil Company has received one of the three annual Poor Richard Almanack awards for the encouragement of careers in science and engineering. The company was asked to distribute a quarter of a million reprints of a science booster article appearing in company magazine, "Our Sun." The article, which points to the need for engineers and scientists, is now being distributed by 53 science museums throughout the U. S.

★ ★ ★

First shipment of Alberta crude to California has been completed. A total of 118,000 bbl, purchased by Tide Water Associated Oil Company, was delivered in a single tanker shipment to San Francisco; point of embarkation was new terminal of the Trans-Mountain pipe line at Vancouver, British Columbia.

★ ★ ★

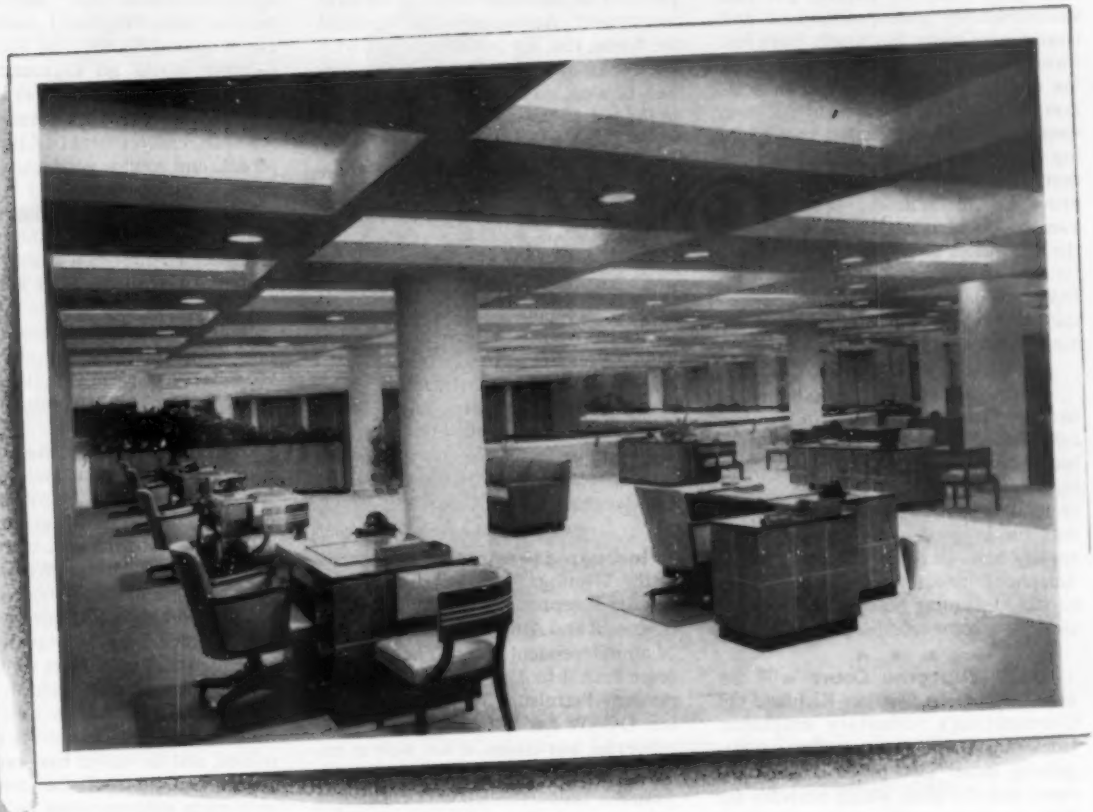
Sahara Petroleum Company is the new name adopted by the Egyptian-American Oil Company, a subsidiary of Continental Oil Company operating in Egypt. The name change was advisable because of difficulty of the Arabic-speaking nationals in pronouncing the word "Egyptian." Consideration was also given to the similarity of names of other oil firms operating in that country.

★ ★ ★

Carter Oil Company plans 1956 capital expenditures of $48,000,000, reflecting a 20 per cent increase over 1955 spending. Substantial portion will go for extensive exploration and production work in most of the company's 25 operating states. About $3,500,000 will be spent in marketing operations in nine western states and $1,000,000 for additions to its Billings, Montana, refinery facilities.

Product research center for Cities Service Company will be soon erected on a 100-acre tract in Cranbury, New Jersey. Some 150 scientists and technicians will work in the new one-story building, which contains offices, repair shop, library and 11 laboratories with testing devices and apparatus ranging from automobile dynamometer testing equipment to sound-proofed rooms in which wind conditions will be simulated.

WHERE OIL WELLS BEGIN...



This is a picture of a part of the Oil Department at Republic. Behind long lines of doors to the right and left is a complete staff of experienced oil men, engineers and geologists.

Behind *them* is the financial strength and the oil "know-how" of one of the first banks to make Oil Production Loans. Production loans originated here have helped add billions of barrels to the nation's oil and gas reserves — and have made the Republic "*The* Oil Bank" to oil men all over America.

This is YOUR Republic
Call it "My Bank"

The Financial Center of the Southwest

REPUBLIC
NATIONAL BANK of Dallas

MEMBER FEDERAL DEPOSIT INSURANCE CORPORATION

CAPITAL AND SURPLUS $70,000,000
LARGEST IN THE SOUTH

Fate of the Harris-Fulbright bill was still undecided as this magazine goes to press. The issue, which would guarantee consumers a reasonable field price on natural gas and simultaneously assure abundant and continuing supply, has nearly been lost through many-pointed campaigns of the opposition. Some changes in position and shifting of support has been seen on both sides. Effect of letter-writing campaigns and Senate talking-marathon of Douglas of Illinois may prove fateful. Senator Fulbright, Arkansas, who has attempted to clarify the confusion of issues, says the fight "is not one of control versus decontrol. It is one that revolves around the method of control to be used, around the method of regulation."

★ ★ ★

Antitrust suits against International Business Machines and American Telephone and Telegraph have been settled in history's largest opening of patents. IBM, the government announces, must release "certain" patents on a royalty-free or reasonable royalty basis to other firms. American Telephone released over 8700 basic patents, including patents on the transistor and color television.

★ ★ ★

U. S. Supreme Court will be asked to rule on whether Richfield Oil Corporation's voluntary employee stock purchase plan is a collective bargaining issue. Two lower courts have ruled that the plan, which provides for joint company-employee contributions, was subject to union negotiation. Oil industry sources say such action would cause companies to shy away from such plans without strong guarantees that they are separate and distinct from wage contracts; too, Richfield said the decision puts workers on both sides of the bargaining table as stockholders and employees.

★ ★ ★

Labor shortage in the U. S. is inevitable, with a possible 76 billion manhour vacuum by 1976, predicts a Du Pont employee magazine article. Only by automation and similar technological improvements can the nation hope to avoid such a shortage, the article claims. The U. S. will need to produce $750 billion annually in goods and services for a population of 216,000,000, estimated in 1976.

★ ★ ★

Automatic control equipment in industrial use has increased some 700 per cent in the last 25 years, as compared with an increase in the general economy of 325 per cent. Control equipment manufacturers say 1956 will be the brightest year ever known for that industry, pointing to the 8 to 10 per cent in automatic controls of total investment. Automation has invaded the home, too, say manufacturers, who list a total of 17,000,000 home heating installations, an increase of 40 per cent in the last 10 years.

★ ★ ★

Restriction of competition accusations have been brought against three oil companies by the Federal Trade Commission over the sale of tires, batteries and auto accessories through service stations. FTC contends that the companies "contract to influence unduly" their affiliated stations to handle tiremakers' products of a particular company. The companies, which state their merchandising methods are fair and valid, are Shell, Atlantic Refining, and The Texas Company. They are linked, respectively, with Firestone, Goodyear and B. F. Goodrich.

★ ★ ★

Indiana Standard employees at the Whiting, Indiana, refinery have rejected representation of the Oil, Chemical and Atomic Workers in favor of an independent union. The vote was more than 4 to 1 in favor of the Independent Petroleum Workers of America. OCAW has lost control in several refineries, but claims it has won in recent elections at General Petroleum's Ferndale refinery, Shell Oil's Anacortes refinery and Great Northern's Pine Bend, Minnesota, refinery.

★ ★ ★

Panhandle Oil Corporation, Dallas, Texas, has agreed to sell 600,000 shares of common stock to Petrofina, Belgian-owned international oil company. Unissued stock, valued at $11.25 per share, will be used in the transaction. Petrofina will receive a three-year option on an additional 270,000 shares. Panhandle and its subsidiaries operate oil and gas production, pipe lines, refining and marketing outlets in Texas and several other southwestern states.

★ ★ ★

East Coast heating oil prices moved higher and stocks continued to deminish in January. Esso Standard posted prices on marine diesel and heating fuels 10 to 13 cents higher early in the month, reflecting strong demand and higher transportation costs from Gulf Coast refineries. Distillates and kerosine supplies dropped 6,503,000 bbl in the first week of 1956. Stocks of gasoline, following the seasonal trend, increased slightly.

★ ★ ★

Bureau of Mines has asked for appropriations of $4,473,600 for its fiscal year beginning July 1, against present budget of $3,887,720. Most of the increase would go to routine salary raises and slightly larger expenditures for operation of helium plants, oil shale research, enforcement of Connally hot oil act, and routine services.

★ ★ ★

"Clearing house" library has been approved by the Interstate Oil Compact Commission executive committee. An expenditure of $20,000 has been awarded the project for use in 1956. Purpose of the library is to locate printed material on conservation information and make it available through the clearing house.

★ ★ ★

Employee investments in oil companies other than their own, may soon get a court test. Many major companies have had rules against such investments, but with little concern. Oil, Chemical and Atomic Workers union have protested The Texas Company policy, on which reminder was issued in December. The company bulletin suggested that employees would be dismissed for failure to conform to the investment ruling. Union officials have indicated workers will strike if anyone is fired, and the matter has been brought to the attention of the Senate antimonopoly subcommittee as a possible violation of "economic independence of Texas employees."

★ ★ ★

Statement of costs, profits and federal taxes would be required of sellers of petroleum products, if a newly introduced House bill is passed. The bill, introduced by Rep. Heselton of Massachusetts, has been sent to the House committee on interstate and foreign commerce. The congressman commented "I know of no reason why purchasers (of oil products) should not know where their dollars and cents go."

★ ★ ★

Venezuelan oil concessions are now open to foreign companies, President Marcos Perez Jimenez announced. The plan is designed to increase oil reserves in that country, create more refining and oil-based industries and attract capital which might otherwise be invested elsewhere. Fourteen oil companies are already operating in Venezuela producing about 2,124,000 bbl daily. Most of this oil is exported to the U. S.

The PEOPLE . . . .

. . . *who support the* SERVICE TEAM

The TEIA Salesman-Serviceman, the Underwriter, the Safety Engineer, the Claim Man, the Payroll Auditor . . . these are the members of the TEIA SERVICE TEAM directly providing you with the best possible Workmen's Compensation Insurance SERVICE.

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TEXAS' *Largest Writer of*
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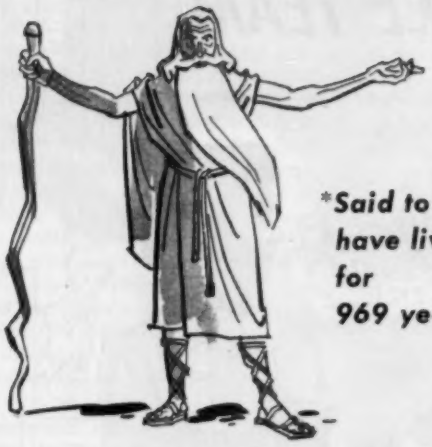
HOME OFFICE - DALLAS, TEXAS

A MOTOR FOR METHUSELAH*



*Said to have lived for 969 years

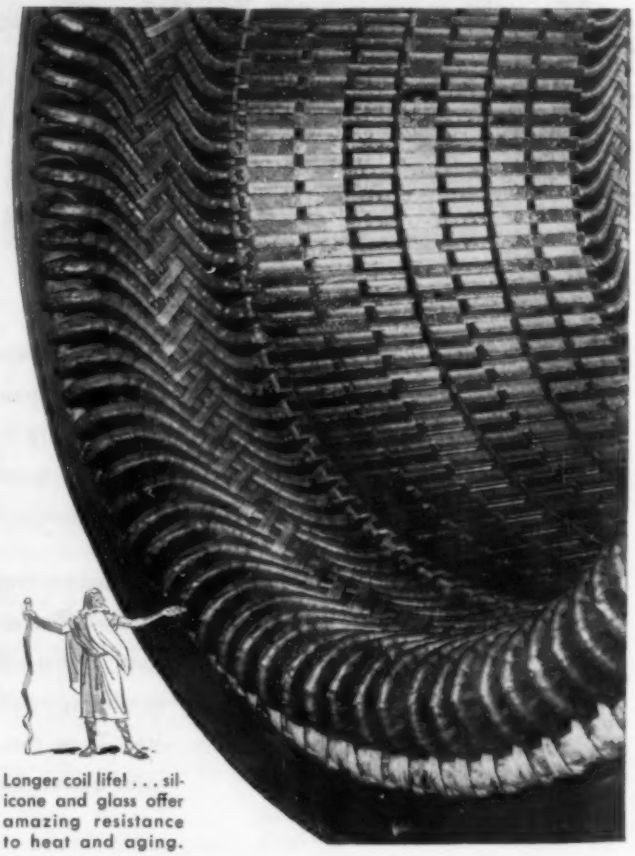
(Above) SIL-CLAD *Weather-Protected motor for outdoor pump drive on Gulf Coast.*
(Below) A portion of silicone and glass insulated coils of the SIL-CLAD *motor.*

SILICONE AND GLASS... two age-defying materials that can't be beat! They are engineered into the E-M Sil-Clad Motor winding shown to the right. Each coil is armored and sealed with glass-backed silicone rubber insulation baked on at 400 degrees F.... each coil-end is lashed with stout glass cord.

Sil-Clad insulation gives an amazing new boost to life expectance of the motor winding. Operating at Class B temperature rise this winding resists heat and aging so perfectly, that temperature practically ceases to be a factor in the life of the coils.

Thus with a Sil-Clad Motor you won't need to baby the coils. You can apply the Sil-Clad Motor with carefree assurance that the winding, at rated operation is perfectly heat resistant. Furthermore you have *extra assurance* that the winding can take real punishment in high ambients, or in overloads and peak load crowding without heat deterioration.

In salt-air or corrosive atmospheres also, Sil-Clad coils resist deterioration because silicone and glass are inert. For your large, tough motor applications in adverse locations you'll want to consider Sil-Clad. It offers real savings over TEFC Motors. Get the full facts from your E-M Field Engineer. And write the factory for Publication No. 1119.



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Specialists in making motors do exactly what you want them to

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Meetings

Feb. 19-23—**American Institute of Mining and Metallurgical Engineers,** annual, Statler Hotel, New York, New York.

Feb. 24—**Natural Gasoline Association of America,** Permian Basin regional, Lincoln Hotel, Odessa, Texas.

Feb. 26-29—**American Institute of Chemical Engineers,** Statler Hotel, Los Angeles, California.

Feb. 27-29—**American Association of Petroleum Geologists,** Rocky Mountain division, Auditorium, Denver, Colorado.

Feb. 27-March 2—**American Society for Testing Materials,** committee week, Hotel Statler, Buffalo, New York.

March 7-9—**American Petroleum Institute,** Division of Production, Southern district, Plaza Hotel, San Antonio, Texas.

March 12-16—**National Association of Corrosion Engineers,** annual, Statler Hotel, New York, New York.

March 19-21—**Mid-West Gas Association,** Hotel Fontenelle, Omaha, Nebraska.

March 19-20-21—**Western Petroleum Refiners Association,** annual, Plaza Hotel, San Antonio, Texas.

March 21-23—**American Petroleum Institute,** Division of Production, Southwestern district, Texas Hotel, Fort Worth, Texas.

March 21-23—**American Power Conference,** annual, sponsored by Illinois Institute of Technology, Hotel Sherman, Chicago, Illinois.

March 22-23—**New England Gas Association,** annual meeting, Statler Hotel, Boston, Massachusetts.

March 24—**North Texas Oil and Gas Association,** annual, Wichita Falls, Texas.

April 2-4—**American Institute of Electrical Engineers,** Southwest district No. 7, Dallas, Texas.

April 3-5—**Annual Corrosion Control Short Course,** University of Oklahoma Extension Study Center, Norman, Oklahoma.

April 4-6—**American Gas Association,** General Management Section, spring conference, Conrad Hilton Hotel, Chicago, Illinois.

April 4-6—**American Petroleum Institute,** Division of Production, Mid-Continent district, Broadview Hotel, Wichita, Kansas.

April 9-10—**Ninth Oil Recovery Conference,** a symposium on "Natural Gas in Texas," sponsored by Texas Petroleum Research Committee, Texas Memorial Student Center, Texas A&M College, College Station, Texas.

April 11-13—**Natural Gasoline Association of America,** annual, Texas Hotel, Fort Worth, Texas.

April 14-19—**Petroleum Equipment Suppliers Association,** Boca Raton, Florida.

April 15-17—**Texas Independent Producers and Royalty Owners Association,** Statler Hilton Hotel, Dallas, Texas.

April 18-20—**National Petroleum Association,** semiannual meeting, Cleveland Hotel, Cleveland, Ohio.

April 18-20—**American Petroleum Institute,** Division of Production, Rocky Mountain district, Cosmopolitan Hotel, Denver, Colorado.

April 19-21—**Indiana Gas Association,** French Lick Springs Hotel, French Lick, Indiana.

April 23-25—**Southern Gas Association** convention, annual, Statler Hilton Hotel, Dallas, Texas.

April 23-26—**American Association of Petroleum Geologists, Society of Economic Paleontologists and Mineralogists,** annual meeting, Conrad Hilton Hotel, Chicago, Illinois.

you save engineering time with complete hanger assemblies

To save many hours of engineering time and to speed up your specifications, use Blaw-Knox overhead roller assemblies, rigid hanger assemblies, functional spring hangers with the patented *internal swivel action*, constant support spring hangers and vibration eliminators.

Each is a complete unit, designed for a specific purpose. Constructed to comply with the "code for pressure piping." Available in types and sizes to meet varying conditions.

And each is ready to install, which eliminates expensive cutting, threading and assembling in the field.

Our experienced engineers are available to both design and make recommendations for your hanger requirements.

Write for your copy of Bulletin No. 54 to get complete information

BLAW-KNOX COMPANY
Power Piping and Sprinkler Division
Pittsburgh 33, Pennsylvania

BLAW-KNOX

PIPE HANGERS

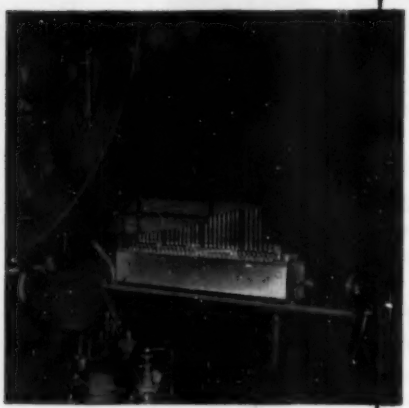
Complete line of functional spring hangers • constant support spring hangers • rigid hanger assemblies • overhead roller assemblies • supports • vibration eliminators . . . plus complete prefabricated piping systems for all pressures and temperatures

Manzel

FORCE-FEED LUBRICATION

Pressure Application—Exact Amounts—Accurately Timed

ENGINEERED TO THE SPECIFIC NEEDS OF THE OIL AND GAS INDUSTRIES



Manzel Force Feed Lubricators in various models are available with from one to 30 feeds and for operation against discharge pressures of up to 30,000 PSIG. They can be engineered into your new equipment or installed on that already in service.

For dependable, automatic lubrication under pressure, Manzel Force Feed Lubricators deliver exactly the right amount of lubricant, to exactly the right places, at exactly the right times. They cut labor — reduce oil consumption — prevent costly breakdowns.

Manzel has had vast experience in meeting the specific needs of the oil and gas industries. When you have lubrication problems, call Manzel.

AND CHEMICAL FEEDERS, TOO

Manzel also produces Chemical Feeders with capacities from a few drops to 60 gallons per hour. Whatever your needs Manzel can fill them with equipment that is sturdily built, simply designed and completely dependable.

Manzel

Professionally qualified engineering representatives throughout the country.

DIVISION OF
HOUDAILLE INDUSTRIES, INC.
291 BABCOCK ST., BUFFALO 10, N. Y.

April 25-27—**American Petroleum Institute,** Division of Production, Eastern district, Statler Hotel, Deshler-Hilton Hotel, Columbus, Ohio.

April 25-29—**World-Oil Exposition,** Houston, Texas.

April 26-27—**American Institute of Electrical Engineers,** national meeting, Bradford Hotel, Boston, Massachusetts.

May 1-3—**Petroleum Industry Electrical Association and Electrical Suppliers Association,** annual conference and exhibits, Statler Hilton Hotel, Dallas, Texas.

May 6-9—**Liquefied Petroleum Gas Association,** convention and show, Conrad Hilton Hotel, Chicago, Illinois.

May 6-9—**American Institute of Chemical Engineers,** Roosevelt Hotel, New Orleans, Louisiana.

May 10-11—**American Gas Association** gas supply, transmission and storage conference, Conrad Hilton Hotel, Chicago, Illinois.

May 10-11—**American Petroleum Institute,** Division of Production, Pacific Coast district, Statler Hotel, Los Angeles, California.

May 14-15—**American Institute of Mining and Metallurgical Engineers,** Formation Fracturing Symposium, Wichita, Kansas.

May 14-16—**American Petroleum Institute,** Pipe Line conference, Shamrock Hotel, Houston, Texas.

May 14-16—**Petroleum Electric Power Association,** 27th annual meeting, Driscoll Hotel, Corpus Christi, Texas.

May 14-17—**American Petroleum Institute,** Division of Refining, midyear meeting, Montreal, Canada.

May 17-18—**American Institute of Mining and Metallurgical Engineers,** joint meeting of Rocky Mountain Petroleum Sections, Gladstone Hotel, Casper, Wyoming.

May 22-24—**Pennsylvania Gas Association,** Pocono Manor Inn, Pocono Manor, Pennsylvania.

May 24-25—**Natural Gas and Petroleum Association of Canada,** Sheraton Brock Hotel, Niagara Fal's, Ontario, Canada.

June 17-22—**American Society for Testing Materials,** Pacific Coast meeting, Hotel Statler, Los Angeles, California.

June 25-29—**The American Society for Engineering Education,** annual meeting, Iowa State College, Ames, Iowa.

June 26-29—**Canadian Gas Association,** Manoir Richelieu, Murray Bay, Quebec, Canada.

Sept. 9-12—**American Institute of Chemical Engineers,** William Penn Hotel, Pittsburgh, Pennsylvania.

Sept. 10-14—**International Congress on Catalysts,** Bellevue-Stratford Hotel, Philadelphia, Pennsylvania.

Sept. 11-13—**Pacific Coast Gas Association,** annual meeting, Coronado, California.

Sept. 12-14—**Third Annual Electrical Conference of the Petroleum Industry,** sponsored by American Institute of Electrical Engineers and Kansas City Section of AIEE, Kansas City, Missouri.

Sept. 16-22—**American Society for Testing Materials,** Pacific Coast meeting, Hotel Statler, Los Angeles, Ca'ifornia.

Oct. 1-5—**American Institute of Electrical Engineers,** Morrison Hotel, Chicago, Illinois.

Nov. 12-15—**American Petroleum Institute,** annual meeting, Chicago, Illinois.

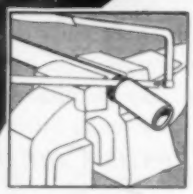
Oct. 14-17—**American Institute of Mining and Metallurgical Engineers,** Petroleum branch, Fall meeting, Biltmore Hotel, Los Angeles, California.

Oct. 25-26—**Independent Petroleum Association of America,** annual membership, Mayo Hotel, Tulsa, Oklahoma.

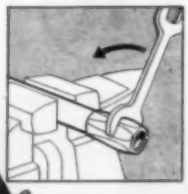
Nov. 19-20—**American Institute of Mining and Metallurgical Engineers,** North Texas Secondary Recovery Symposium, Wichita Falls, Texas.

STRATOFLEX

HOSE and FITTINGS



1. Cut hose to length.



2. Screw on socket.

3. Oil inside and insert assembly tool.

4. Screw swivel nipple or male fitting into socket and remove tool.

Save Time . . . Cut Costs

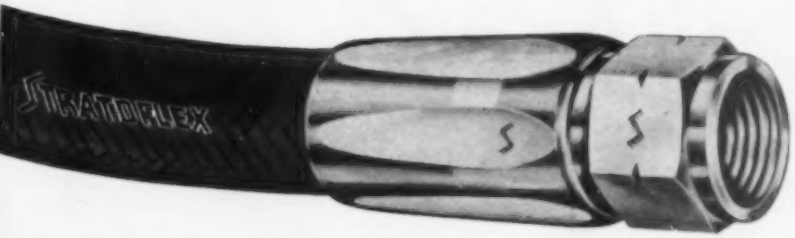
. . . in equipping new rigs or replacing worn hose assemblies. Stratoflex hose is highly resistant to abrasion and corrosion. Fittings are detachable and reusable — will not vibrate loose and are leak-proof. Your nearby Mid-Continent Supply Store stocks Stratoflex hose and fittings for hydraulic, pneumatic, fuel and oil lines.

Complete Hose Assemblies

. . . in stock in many sizes and lengths . . . or made up promptly to your specifications.

Bulk Hose and Re-usable Hose Fittings

. . . for making up your own hose assemblies in the field. Simple four-step assembly shown at left is quick and economical.



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MID-CONTINENT Supply Company

MID-CONTINENT BLDG. • FORT WORTH, TEXAS

THE WORLD'S LARGEST INDEPENDENT OIL FIELD SUPPLY COMPANY

Roughnecks...

Did you ever watch a good team of roughnecks in action? They make the orderly racking of the long sections of drill pipe and the handling of other heavy "pig iron" look easy. When the replacement of a dull bit interrupts the quest for pay sand, they're hustling: hoisting, disconnecting and racking drill pipe to get a new bit back on bottom and start making hole again—for "making hole" is making money and every minute saved in other operations is money saved, and a lot of it. That's where the skill and teamwork of good roughnecks make the difference.

The Texas Company

TEXACO

What's going on underground?

UNDERGROUND, drill pipe and casing take a terrible beating.

Drill pipe is limber. Under torque it spirals as it rotates—suffers severe bending stress, fatigue, wobble, and twisting action.

Casing, in turn, is subjected to tremendous pressures and vibrations in deep wells. It *must* possess great joint strength and high collapse resistance.

National Seamless Drill Pipe and Casing can take this kind of punishment in stride . . . Ask the oil men!

National Seamless Oil Country Tubular Products are acknowledged the world over as the ideal material for deep well work, from the standpoint of both steel quality and method of manufacture. Piercing a steel billet to form a seamless tube is one of the most difficult forging operations in the steel industry. Only steel of the very best forging properties and of high uniformity can be used for the seamless process, since the piercing operation tends to search out any defects in the metal.

For dependable drill pipe, casing and tubing that can "take it"—material that will give you *more service per dollar invested*, remember to specify USS National Seamless . . . every time!

Here are some of National Tube's contributions to the Oil and Gas Industry . . .

National Deoxidized Bessemer Steel Casing and Tubing—Grades H-40, J-55

Especially well-suited for oil production because of its combination of high yield strength and good ductility.

National Warm-Worked Casing—Grade N-80

An extremely high-strength casing possessing a uniformity of physical properties which gives it high collapse resistance and greatly increased joint strength. It is hydrostatically tested to 80% of minimum yield strength up to a maximum of 10,000 p.s.i.

National Deep-Well Casing

A stronger casing than is provided under A.P.I. specifications, to meet constantly increasing depths. Due to the severe service for which it is intended, it is hydrostatically tested to 80% of minimum yield strength up to a maximum of 12,000 p.s.i.

National (B) Buttress-Thread Casing

Developed to satisfy the need for a casing joint which will safely and economically support the weight of a deep-well casing. The buttress-thread joint is comparable in strength to that of the body of the pipe.

For further information, write to National Tube Division, United States Steel Corporation, 525 William Penn Place, Pittsburgh 30, Pa. Ask for Bulletin No. 15.

WALLS WITHOUT WELDS

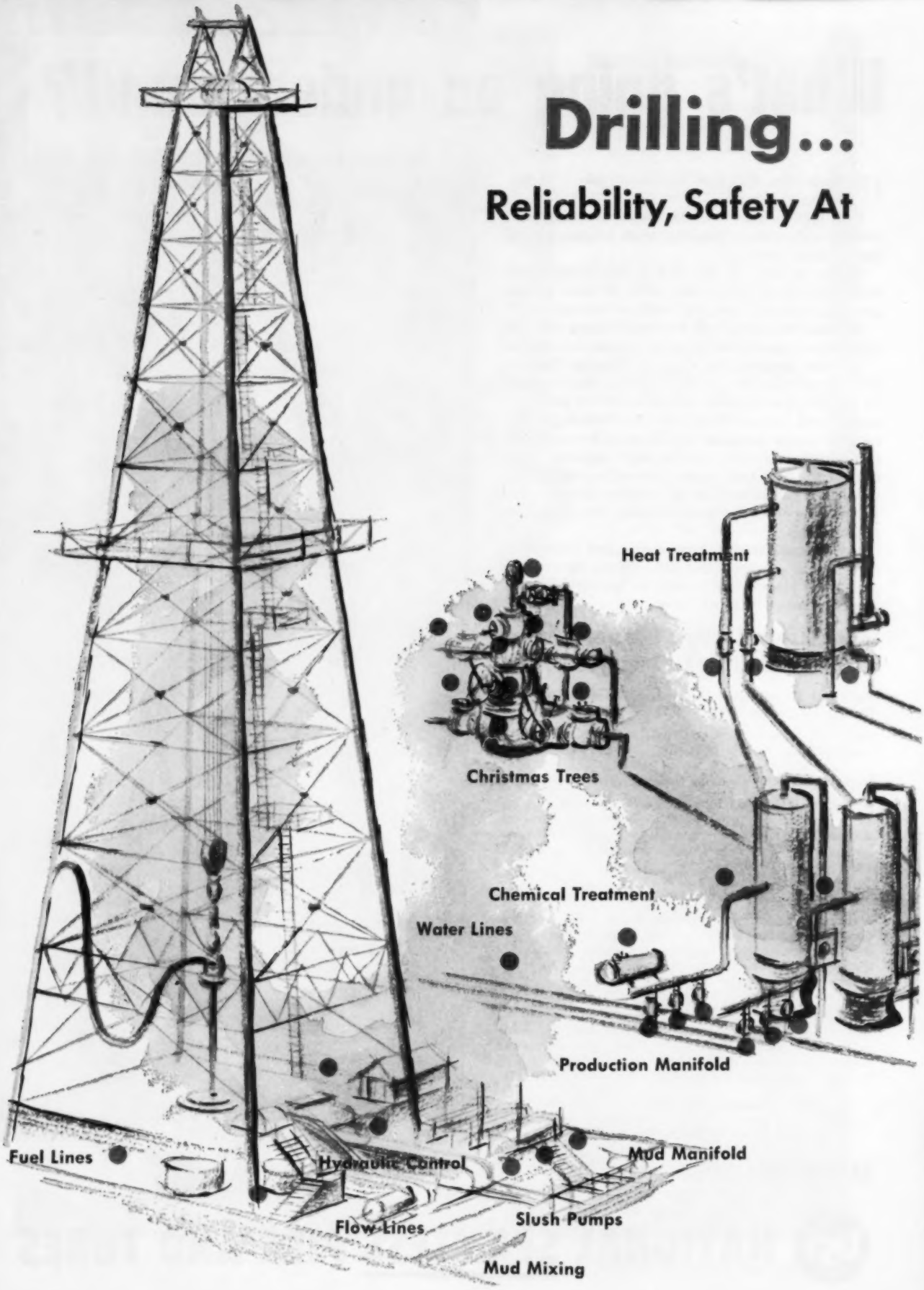
NATIONAL TUBE DIVISION · UNITED STATES STEEL CORPORATION, PITTSBURGH, PA.
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS **NATIONAL SEAMLESS PIPE AND TUBES**

UNITED STATES STEEL

Drilling...

Reliability, Safety At



Completion...Production

Every Step With ROCKWELL-Nordstrom VALVES

Field men depend on Rockwell-Nordstrom valves for reliable, safe flow control. They know that Rockwell-Nordstrom exclusive Sealdport* lubrication assures leakproof, positive shut-off and instant, quarter-turn operation that can't be had in ordinary valves.

The dependability of Rockwell-Nordstrom valves has been proved by forty years of service throughout the oil and gas industries. They can't be matched from any standpoint, yet they cost no more to buy, often less than ordinary valves. For more information, call your supplier or write: Rockwell Manufacturing Company, Pittsburgh 8, Pa.

Canadian Valve Licensee: Peacock Brothers Limited.

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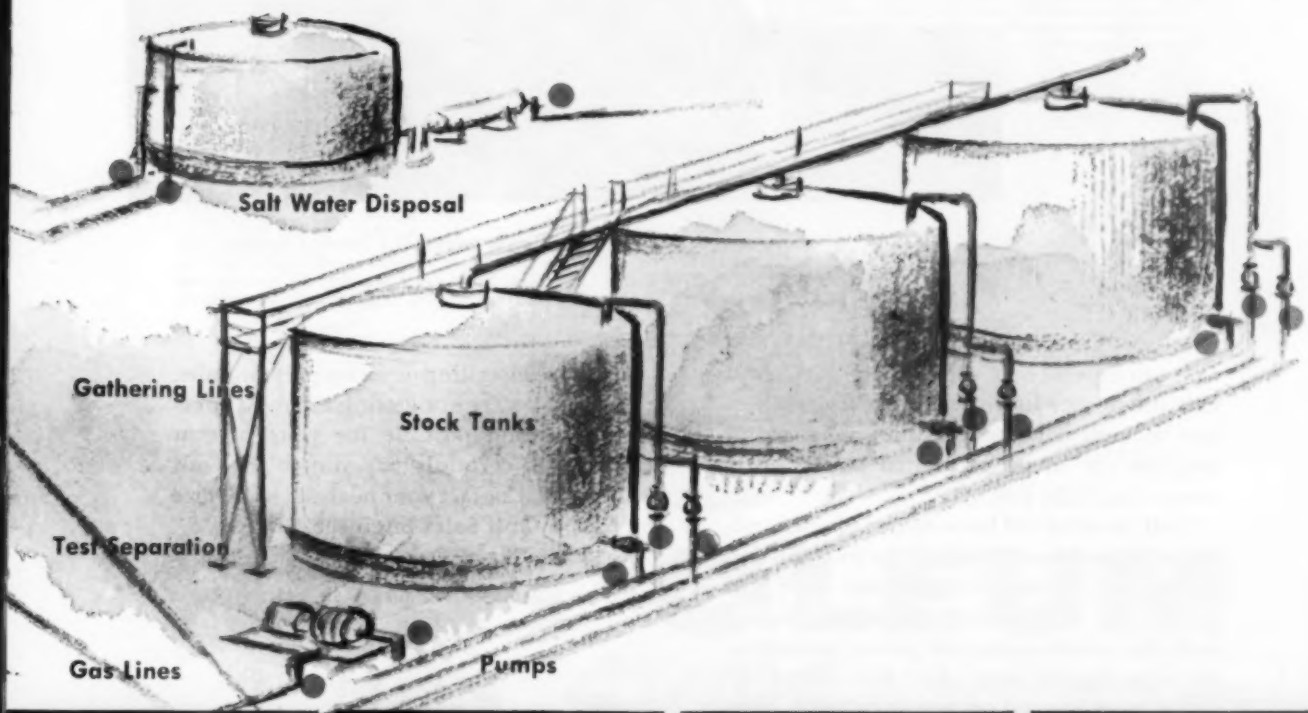
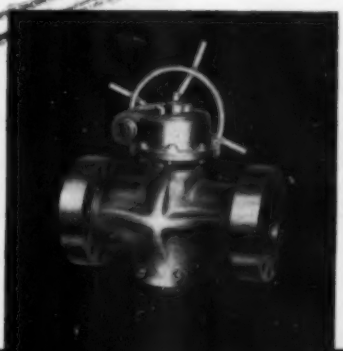
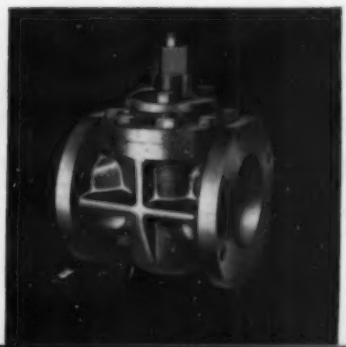
ROCKWELL-Nordstrom VALVES

Lubricant Sealed for Positive Shut-Off

40th YEAR *of lubricated plug valve leadership*

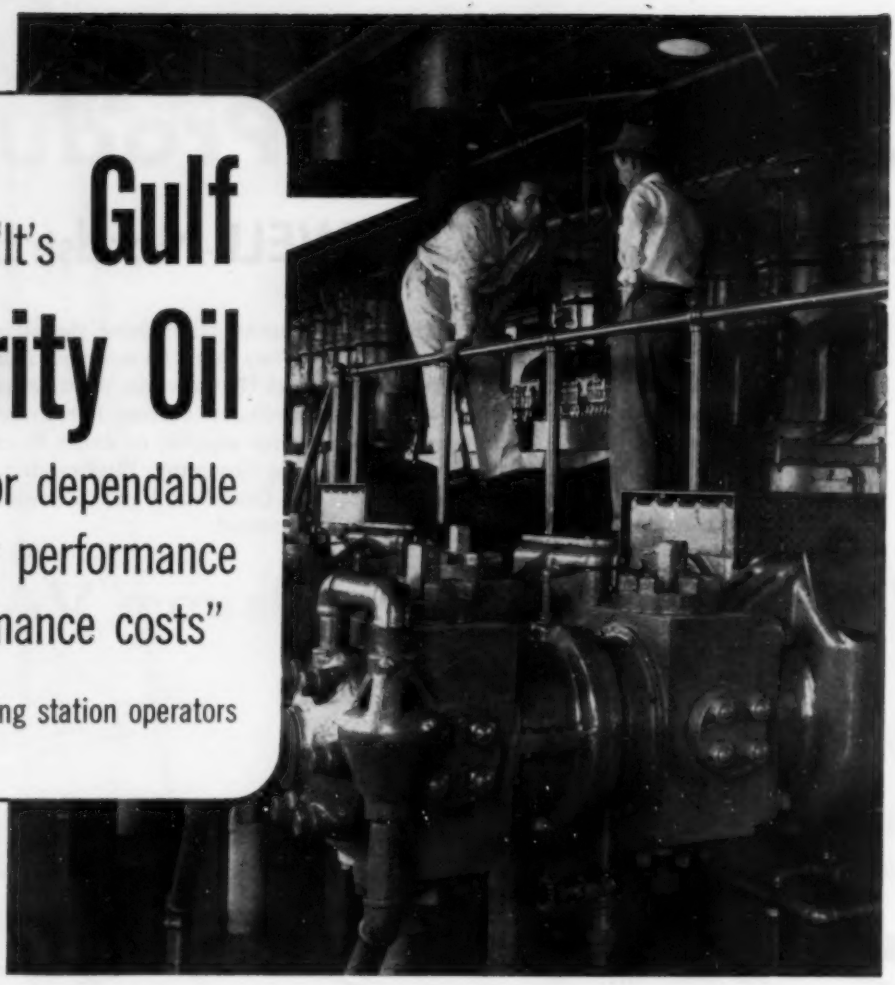






"It's Gulf Security Oil for dependable gas compressor performance and low maintenance costs"

say pumping station operators



Smooth, continuous operation is a must for these units in service at a South Texas gas compressor plant. They are responsible for the steady flow of essential natural gas through pipe lines to homes and industries as far north as Detroit and New York. Gulf Security Oil provides the sure, effective protection needed for cylinders and bearings in both engines and compressors.

You can depend on Gulf Security Oil to provide the proper lubrication that is so important to vital compressor units if operating troubles are to be prevented and maintenance costs kept low.

Gulf Security Oil has a record of outstanding performance in scores of gas transmission plants. After years of operation with this quality oil, the cylinders and piston rings of both the compressors and power assemblies show negligible wear. And few carbon deposits have formed on power cylinder ports and pistons.

If you are installing new compressor units, or feel that you're not getting the most effective lubrication possible for your present units, it will certainly pay you to try Gulf Security Oil. Contact your nearest Gulf Office and have a Gulf Sales Engineer call.

Gulf Oil Corporation • Gulf Refining Company

1822 GULF BUILDING, PITTSBURGH 30, PENNSYLVANIA

GULF

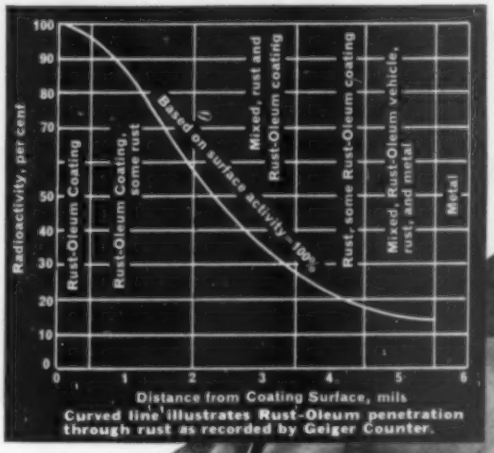
The finest petroleum products for your every need

RUST-OLEUM®

PENETRATION

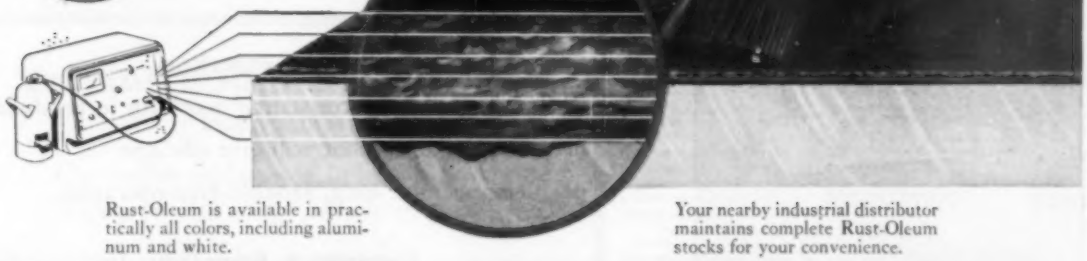
through rust to bare metal traced by Geiger Counter. To effectively stop rust—the vehicle of a protective coating, when applied over a sound, rusted surface—must penetrate through the rust down to bare metal. **Rust-Oleum does exactly that!—as proved by radioactive research!** Rust-Oleum's specially-processed fish oil vehicle was radio-activated and formulated into Rust-Oleum 769 Damp-Proof Red Primer—then applied to rusted test panels. Penetration *through rust* to bare metal by Rust-Oleum's specially-processed fish oil vehicle was then traced by Geiger Counter.

You stop rust, because Rust-Oleum's fish oil vehicle soaks deep down to bare metal and into the tiny pits where it drives out air and moisture that cause rust. You save, because this same *penetration* enables you to apply Rust-Oleum directly over rusted surfaces—usually eliminating costly surface preparations. Attach coupon to your letterhead for your thirty-page report entitled, "The Development of a Method To Determine The Degree of Penetration of a Rust-Oleum Fish-Oil-Based Coating Into Rust On Steel Specimens," prepared by Battelle Memorial Institute technologists.



Curved line illustrates Rust-Oleum penetration through rust as recorded by Geiger Counter.

There is only one Rust-Oleum. It is distinctive as your own fingerprint. Accept no substitute. Buy—and specify only Rust-Oleum. You'll be happy that you did.



Rust-Oleum is available in practically all colors, including aluminum and white.

Your nearby industrial distributor maintains complete Rust-Oleum stocks for your convenience.

RUST-OLEUM®

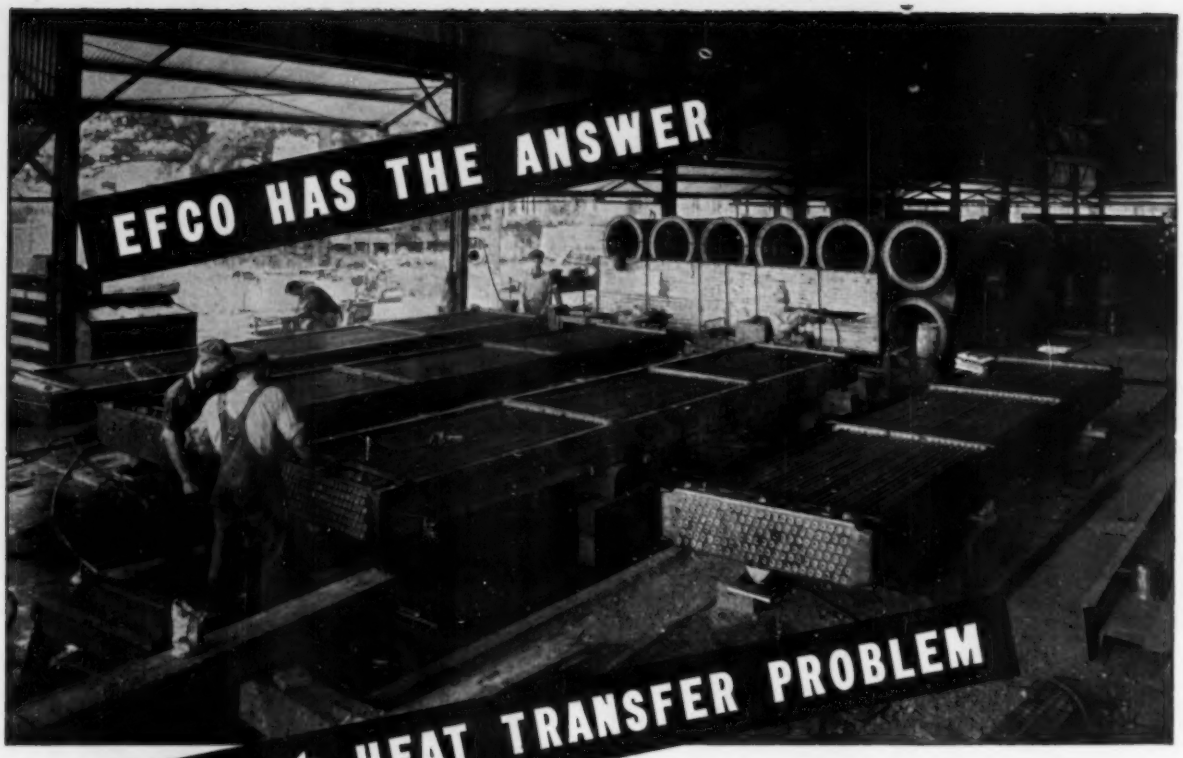
STOPS RUST!

See our Catalog in Sweets, or write for complete information.

ATTACH TO YOUR LETTERHEAD—MAIL TODAY

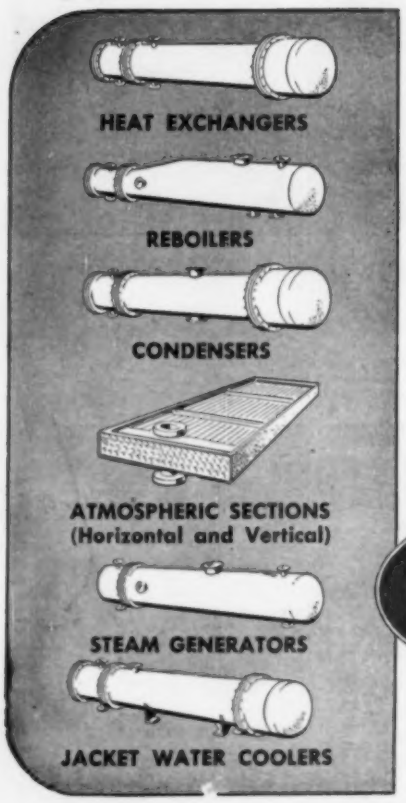
Rust-Oleum Corporation
2551 Oakton Street
Evanston, Illinois

- ☐ Complete literature including color charts.
- ☐ Thirty-page report on Rust-Oleum penetration.
- ☐ Nearest source of supply.



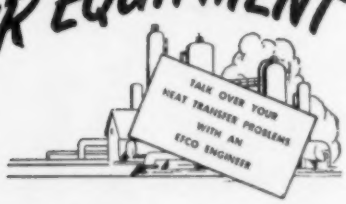
If your problem is the poor performance or high maintenance cost of your heat transfer units, consult an EFCO engineer. He will help you decide the changes or modifications necessary to get the desired performance from your heat transfer equipment.

Backed by knowledge and experience, EFCO engineers are constantly working to produce heat transfer units that will give efficient performance and long, trouble-free operation.



ENGINEERS & FABRICATORS, INC.
P. O. Box 7395 Houston 8, Texas

EFCO
HEAT TRANSFER EQUIPMENT



GROWING

STATEMENT OF CONDITION

December 31, 1955

ASSETS

Cash on Hand and Due from Banks		$339,562,399.10
United States Government Obligations	$ 88,587,036.89	
Public Housing Authority Obligations (Fully Guaranteed)	4,845,850.48	
State, County, and Municipal Bonds	18,915,140.38	112,348,027.75
Stock in Federal Reserve Bank		1,500,000.00
Other Bonds		3,522,227.27
Bills of Exchange and Commodity Loans		11,390,783.06
Loans and Discounts		362,054,715.53
Income Accrued		2,136,289.96
Letters of Credit and Acceptances		5,182,599.84
Banking House and Equipment		7,941,748.91
Other Assets		129,950.57
		$845,768,741.99

LIABILITIES

Capital Stock	$ 22,000,000.00	
Surplus Fund	28,000,000.00	
Undivided Profits	4,544,893.72	$ 54,544,893.72
Reserved for Contingencies		5,398,381.53
Reserved for Taxes, Etc.		4,679,551.26
Deferred Income		1,894,272.11
Letters of Credit and Acceptances		5,182,599.84
DEPOSITS:		
Individual	$488,070,967.34	
Banks	273,547,927.17	
U. S. Government	12,450,149.02	774,069,043.53
		$845,768,741.99

For the 80th Straight Year Results Tell Us...

the major difference between banks of today is the way people are treated.

Ben Wooten

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80 years of growth through service to people

NATIONAL BANK in Dallas

MEMBER FEDERAL DEPOSIT INSURANCE CORPORATION

GIVE US AN OPPORTUNITY TO SAY... SBA

Complete quality control on drill pipe

"I understand that Youngstown makes its own steel. Ore from Youngstown's own mines is made into steel and then into drill pipe in Youngstown's own mills. And Youngstown watches it all the way. Thus they control quality from ore mines to oil fields.

"Makes sense. Dollars, too. Next time you get drill pipe, ask for Youngstown. The pipe with the orange band.

YOUNGSTOWN
DRILL PIPE
...MADE FOR OIL MEN
BY PIPE MEN

QUALITY YOUNGSTOWN SERVICE

Youngstown
DRILL PIPE

THE YOUNGSTOWN SHEET AND TUBE COMPANY *Manufacturers of Carbon, Alloy and Yoloy Steel*

General Offices Youngstown, Ohio District Sales Offices in Principal Cities.

SHEETS - STRIP - PLATES - STANDARD PIPE - LINE PIPE - OIL COUNTRY TUBULAR GOODS - CONDUIT AND EMT - MECHANICAL TUBING - COLD FINISHED BARS - HOT ROLLED BARS - WIRE - HOT ROLLED RODS - COKE TIN PLATE - ELECTROLYTIC TIN PLATE - BLACK PLATE - RAILROAD TRACK SPIKES - MINE ROOF BOLTS

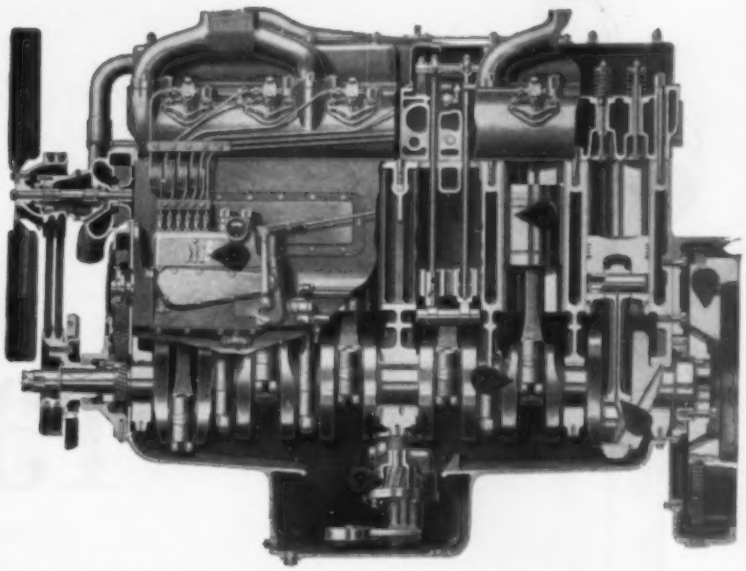
1 FULL FLOW OIL FILTER—Before oil goes under pressure to engine bearings, all harmful particles are removed by replaceable plastic-impregnated, full-flow filters.

2 POSITIVE ROTATORS EXTEND VALVE LIFE. Exhaust valve rotators keep valves turning, at all engine speeds, distributing heat uniformly around the valves to keep deposits from building up on stems and seats, and also to prevent sticking, scuffing, and burning.

3 POSITIVE ALL-WEATHER STARTING. Seconds-fast, International Diesels start in coldest weather on exclusive gasoline starting system. Cylinders are pre-heat conditioned to give complete, clean combustion, instantly, on switching to operation on Diesel fuel.

4 ALUMINUM-ALLOY PISTONS have a thick crown at the top for rapid dissipation of excess heat direct to the cooling water. Hardened, replaceable, cylinder sleeves, three compression rings, with top ring chrome-plated, plus two oil control rings assure long-lasting, gas-tight seal for high compression ratios of over 15 to 1 . . . providing top fuel and oil economy.

5 SIMPLE, SINGLE-HOLE, INJECTION NOZZLE and pre-combustion chamber set at 45° angle for smooth, clean combustion of low grade No. 2 fuel oil under all engine speed and load conditions.



6 NEW IH INJECTION PUMP: Single plunger type on four-cylinder models, twin-plungers on six-cylinders . . . provide all cylinders equal amounts of fuel, precisely metered to load, whether for idling, maximum horsepower, or maximum torque under overload. New, harder injection plungers have up to four times longer life.

7 HEAVY-DUTY FORGED CRANKSHAFT with large diameter, induction-hardened journals provides long-lasting, wear-resistant bearing surfaces . . . rifle-drilled for full pressure lubrication . . . dynamically balanced for smooth operation.

8 REPLACEABLE TRI-METAL BEARINGS provide precision clearance for full-pressure lubrication and thousands of hours of heavy-duty work. Smooth electroplating of white alloy metal over copper-lead, precision bonded to a steel back, carries heavy loads with minimum friction.

9 FULL-PRESSURE LUBRICATION for long life. Big, gear-type pump delivers oil under controlled pressure through full-flow filters and rifle-drilled passages to main and connecting rod bearings, piston pins, camshaft, timing gears, and valve rocker arms.

10 HEAVY FLYWHEEL helps to maintain uniform speed under widely varying load conditions. Available to match standard makes of clutches, fluid couplings, and torque converters.

Hour after hour . . year after year

INTERNATIONAL ENGINES

. . . stay on the job with least upkeep

All International engines are built throughout to give you a full measure of power that stands up and stays on the job. They are precision-manufactured of thoroughly tested materials under continuous, quality-control inspection. Pressure lubrication through rifle-drilled crankshafts and internal passages assures trouble free performance. Inbuilt precision is fully protected from dirt and grit under the worst of job operating conditions by the best of fuel, oil, and air filters.

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There's a size and type of International engine to fit your needs . . . from 16½ to over 200 hp.

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MAKES EVERY LOAD A PAYLOAD

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Since 1940

A record of installations

that in itself is incomparable

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Superior Diesel or Dual Fuel Drilling Engines are available from 300 to 650 Continuous B.H.P. Superior Gas Drilling Engines from 320 to 630 Continuous B.H.P.

Dependable Superior Diesels practically eliminate costly down-time. With minimum maintenance and repairs, they'll power your rig for many more hours between overhauls, under the most rugged, toughest field service! Hundreds of case histories are firm proof too, that Superior's precision construction cuts fuel and lubrication costs to a bare minimum. Dynamically balanced crankshafts provide practically vibration-free operation at all speeds . . . this enables rapid acceleration for quicker round trips and for fast pipe handling . . . and relieves excess wear on all engine accessories.

Make a Superior investment . . . get all the facts from leading rig manufacturers, or through White Diesel field representatives available in all oil field areas or through the White Diesel Engine Division. You'll see convincing proof Superior Diesels are your best investment! And you can continue to invest with confidence because the vast facilities of the White Motor Company are dedicated to carry on intensified research, development and precision manufacturing of Superior and Atlas Diesel, dual fuel, and gas engines for oil field service.

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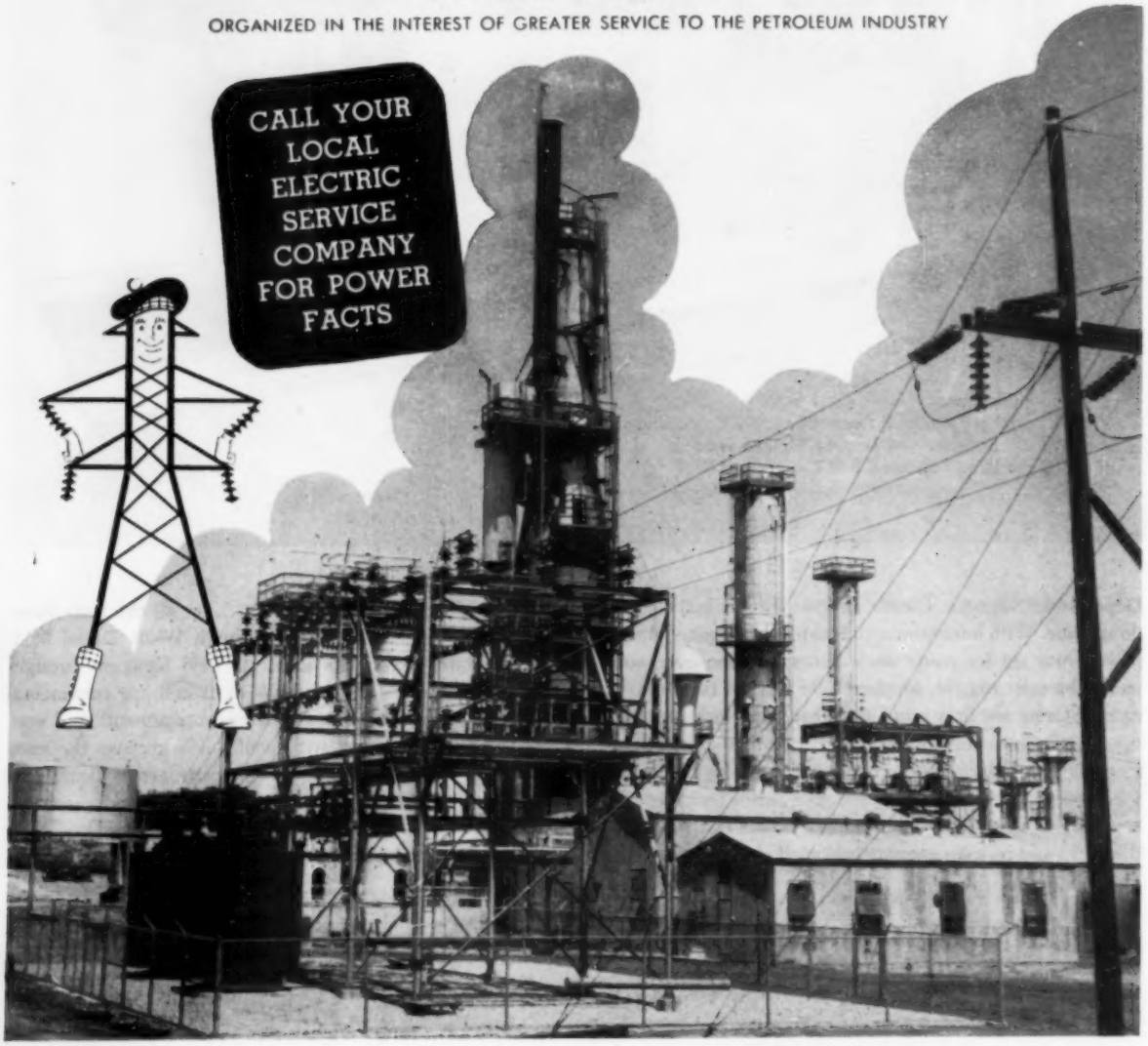
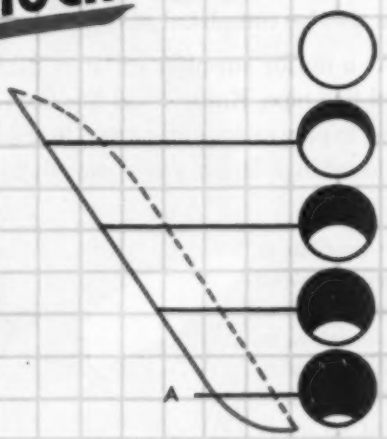
ORGANIZED IN THE INTEREST OF GREATER SERVICE TO THE PETROLEUM INDUSTRY



W-K-M Eclipse Closing . . . takes the SHOCK out of Line Surge



Dotted line shows closing curve of conventional gate valve.

• Regardless of volume or pressure flowing through a W-K-M Valve, it can be closed as fast as required without setting up dangerous surges. In W-K-M Through-Conduit Valves the basic design of the gate and segment provides the right variable ratio of port area to gate travel to close the valve without surging.

The no-surging action of eclipse closing is illustrated by the curve above. From full-open to point A, the rate of closing is almost a straight line. From point A (about 70% closed) the rate of close slows as it approaches the fully-closed position. This gradual close-off at the critical point brings the flow through the valve to a smooth stop rather than a sudden halt—consequently there is no surging.

In addition to this fine feature W-K-M Through-Conduit Valves have many others that make them the leader in long-life, trouble-free performance for every purpose.

W-K-M Valves

W-K-M Manufacturing Company, Inc. P. O. Box 2017, Houston 1, Texas Los Angeles, California

A subsidiary of ACF Industries Incorporated

Export Office: 45 Rockefeller Plaza, New York, N. Y.

Enough to run a pipe line from San Francisco to London

THE gas and petroleum transmission industries can take great pride in the gigantic jobs they've completed in recent years.

As a major supplier of large diameter steel line pipe, Kaiser Steel has been privileged to play an important part in these vast undertakings. In five years, enough line pipe of various diameters has been shipped from our Napa, California plant to run a pipe line from San Francisco to London.

Shown below is a partial list of major customers, who have used Kaiser Steel Line Pipe in scattered locations from New York to California, from Canada to Mexico.

CITIES SERVICE GAS CO.
NORTHERN NATURAL GAS COMPANY
PANHANDLE EASTERN PIPE LINE CO.
SINCLAIR PIPE LINE CO.
INTERPROVINCIAL PIPE LINE CO.
OKLAHOMA NATURAL GAS CO.
PLATTE PIPE LINE CO.
NATURAL GAS PRODUCERS, INC.
THE MONTANA POWER COMPANY
COLORADO INTERSTATE GAS CO.
ARAPAHOE PIPE LINE CO.
TRANS MOUNTAIN OIL PIPE LINE CO.
MOUNTAIN FUEL SUPPLY CO.
SOUTHERN UNION GAS CO.
EL PASO NATURAL GAS CO.
PACIFIC GAS & ELECTRIC CO.
STANDARD OIL COMPANY OF CALIFORNIA
UNION OIL COMPANY OF CALIFORNIA
RICHFIELD OIL CORPORATION
SOUTHERN COUNTIES GAS CO.
TIDE WATER ASSOCIATED OIL COMPANY
SOUTHERN CALIFORNIA GAS COMPANY

Kaiser Steel

GULF OIL CORPORATION
GULF REFINING COMPANY
PHILLIPS PETROLEUM CO.
PHILLIPS PIPE LINE CO.
TENNESSEE GAS TRANSMISSION CO.
THE TEXAS PIPE LINE COMPANY
PIONEER NATURAL GAS COMPANY
TRUNKLINE GAS COMPANY
TRANSCONTINENTAL GAS PIPE LINE CORP.
TEXAS EASTERN TRANSMISSION CORP.
UNITED GAS PIPE LINE COMPANY
ASIATIC PETROLEUM CORPORATION
THE PURE OIL COMPANY
SINCLAIR OIL CORPORATION
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Steel Mill Products: plates • hot rolled strip and sheet • cold rolled strip and sheet • tin plate • continuous weld pipe • electric weld pipe • alloy and carbon bars • bar shapes • structural shapes semi-finished steels • pig iron • ingot molds • coke by-products • **Fabricating Division:** steel fabrication for construction, aircraft, missile and other industries • expanded fusion weld pipe reinforced concrete pipe • tanks • For specifications, write: **KAISER STEEL CORPORATION** • **Los Angeles** • **Oakland** • **Seattle** • **Portland** • **Phoenix** • **Denver** • **Tulsa** • **New York**

Bridging the gap between research and product sales

Throughout the petroleum industry

FLUOR BUILDS PROCESSES INTO PROFITS

First comes research and process development . . . both vital to a growing industry. But then someone must translate the process into a full-scale production facility. Here's a recent example of Fluor's outstanding success in linking these two activities.

Using the process developed by Universal Oil Products Company, Fluor constructed for Gulf Oil Corporation the world's largest Platformer, rated at 29,000 barrels/day. The unit converts a naphtha charge into high-octane motor fuel, and the over-all installation includes individual sections for prefractionation, fixed-bed catalytic reforming, gas treating and fractionation.

Another "first" in Fluor's growing list of refining accomplishments, the Gulf Platformer is typical of the breadth of Fluor services. To the responsibility for mechanical design, engineering, construction and process design, Fluor adds an intangible . . . *dependability*. It's the big reason industry after industry has found that you *can* be sure with Fluor.

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FLUOR
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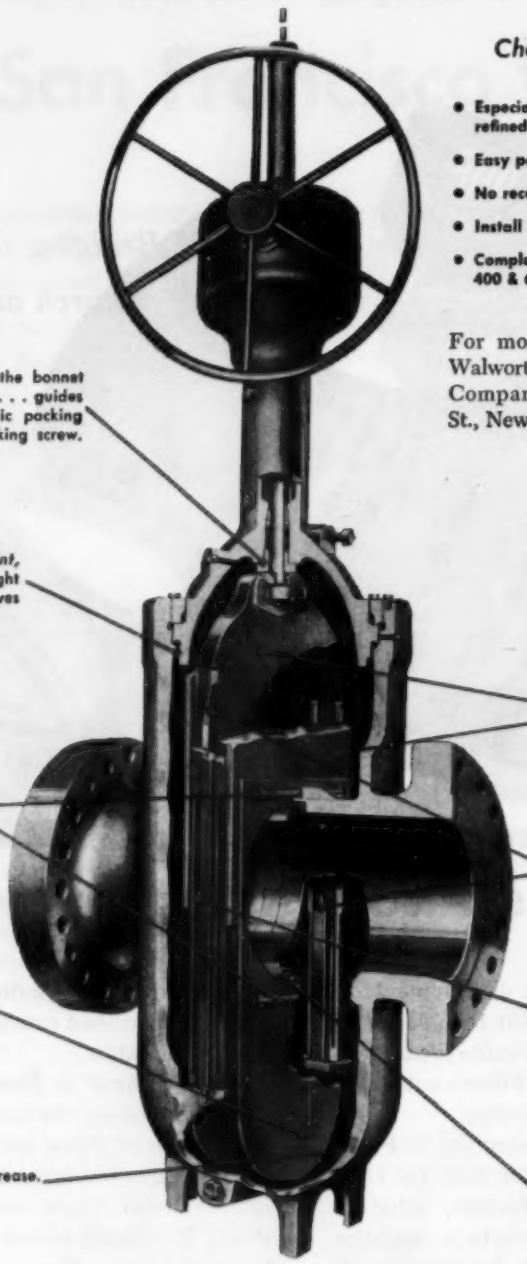
For Gas or Oil Pipelines . . .

HERE'S WHY OILMEN SPECIFY TYPE 49

Check these type **49** *features:*

- **Especially designed for pipelines handling crude oil, refined products, or gas.**
- **Easy passage for pigs or scrapers.**
- **No recesses to trap dirt.**
- **Install in any position, for flow in either direction.**
- **Complete line from sizes 2 to 30 inches in series 400 & 600.**

For more information, see your nearest Walworth Distributor or write to Walworth Company, General Offices, 60 East 42nd St., New York 17, N. Y. Ask for Circular 137.



Bonnet bushing **screws into the bonnet and is tack-welded in place . . . guides the stem, also retains plastic packing which is adjusted by a packing screw.**

Boltless, flangeless bonnet joint, **sealed with ring gasket, stays tight at all pressures. This design saves room, weight.**

Hard chromium-plated discs **resist corrosion, abrasion.**

Loading bars **press disc shield plates axially to wipe discs clean while valve is closing or opening.**

Leakproof closure, **provided by wedging surfaces on each guide and sides of the discs. Wedging surfaces press discs against seat rings.**

Disc shield plates **contact disc faces at all times to prevent dirt from entering the body cavity.**

Loading bars, **incorporated on the disc guides, press the discs axially against the seat rings to provide wiping action between the disc and seat ring faces.**

Valve needs no body-packing grease.

Backseated seat rings screw directly into body **with perfect alignment. Stellite or bronze facing on ring.**

Cutaway of a 16-inch Walworth Type 49 Cast Steel Pipeline Gate Valve

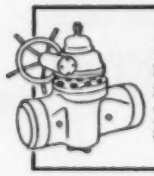
WALWORTH

Manufacturers since 1842

valves . . . pipe fittings . . . pipe wrenches

60 East 42nd Street, New York 17, N. Y.

Walworth Company of Canada, Ltd., Toronto



For quick opening or closing Walworth manufactures lubricated plug valves for pipelines in sizes to 30-inches . . . pressures to 5000 psi and for vacuum service. Ask for literature.

DISTRIBUTORS IN PRINCIPAL CENTERS THROUGHOUT THE WORLD

What UNION CENTRALIZED TRANSPORT CONTROL *can do for you*

UNION Centralized Transport Control can give you reliable remote control and indications for your entire pipeline from one central dispatching office. In effect, it permits the dispatcher to function as if he were actually present at each station under his control.

A Control System recently supplied to a leading pipeline company provides:

1. **Means at the dispatching center** for individual control and operation of pump and valve functions for the control and routing of products.
2. **Complete indications** at the control center of the movements and positions of the controlled functions and for station unit alarms.
3. **Flow information** at the control center in the form of illuminated flow arrows on a graphic display panel.
4. **Telemetering** to indicate and record at the central office interface arrival at a switching center.

UNION Systems are extremely flexible and can be easily modified to meet changing system requirements. Operation is simple and above all—reliable.

UNION Systems are readily adaptable to any means of communications transmission; including telephone circuits, carrier circuits, VHF and UHF radio and microwave or private wire.

UNION Centralized Transport Control can be used on a variety of pipeline layouts, gathering systems, tank farms and offshore applications. It has been thoroughly proved in service and is backed up by our experience in centralized control covering more than 25,000 miles of long haul transportation. Write for information on your single or multiple station control requirements.

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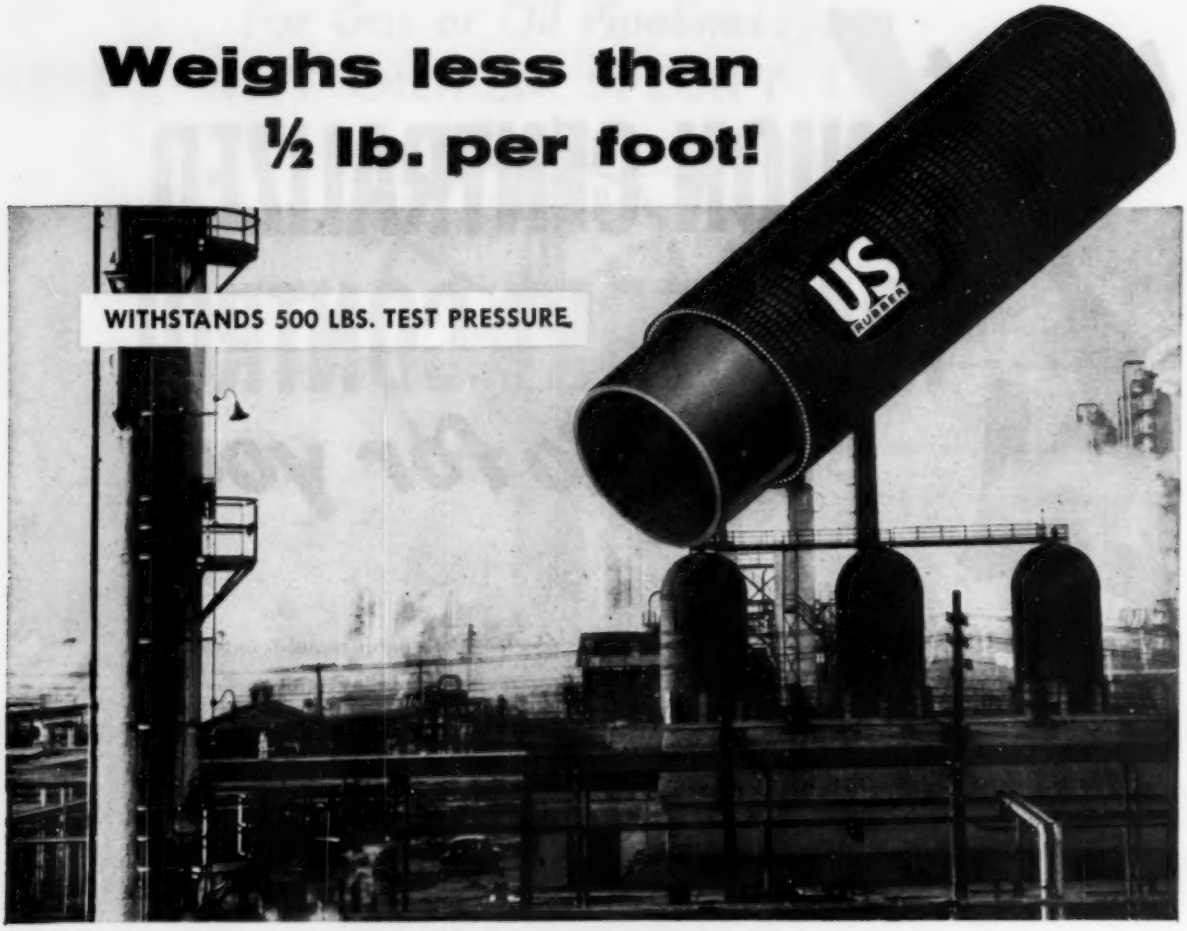
UNION SWITCH & SIGNAL

DIVISION OF WESTINGHOUSE AIR BRAKE COMPANY

PITTSBURGH 18 PENNSYLVANIA

Weighs less than ½ lb. per foot!



The new super-flexible *All-Dacron*

U. S. FLEXLITE® FIRE HOSE!

Its single jacket is all Dacron*—to give the lighter weight, pressure resistance, flexibility, rackability required by today's petro-chemical fire departments.

Although U. S. Flexlite weighs 50% less than conventional hose, it will handle extreme pressures! Its Neoprene tube and Dacron jacket have the required resistance to chemicals, petroleum, mildew, dampness, heat. Coils easily, dries fast. United States Rubber Company also makes the following hose for the petro-chemical field.

(1) "Reliance®" Double Jacket Dacron reinforced (weighs 50 lbs. per 100 ft.) (withstands 400 lbs. test pressure)

(2) "Reliance" Double Jacket Dacron reinforced (weighs 54 lbs. per 100 ft.) (withstands 600 lbs. test pressure)

(3) U. S. Matchless® Carbolized—most rugged hose in the market.

Get in touch with any of our selected distributors or any of the 27 "U. S." District Sales Offices, or write us at Rockefeller Center, New York 20, New York.

*DuPont's polyester fiber

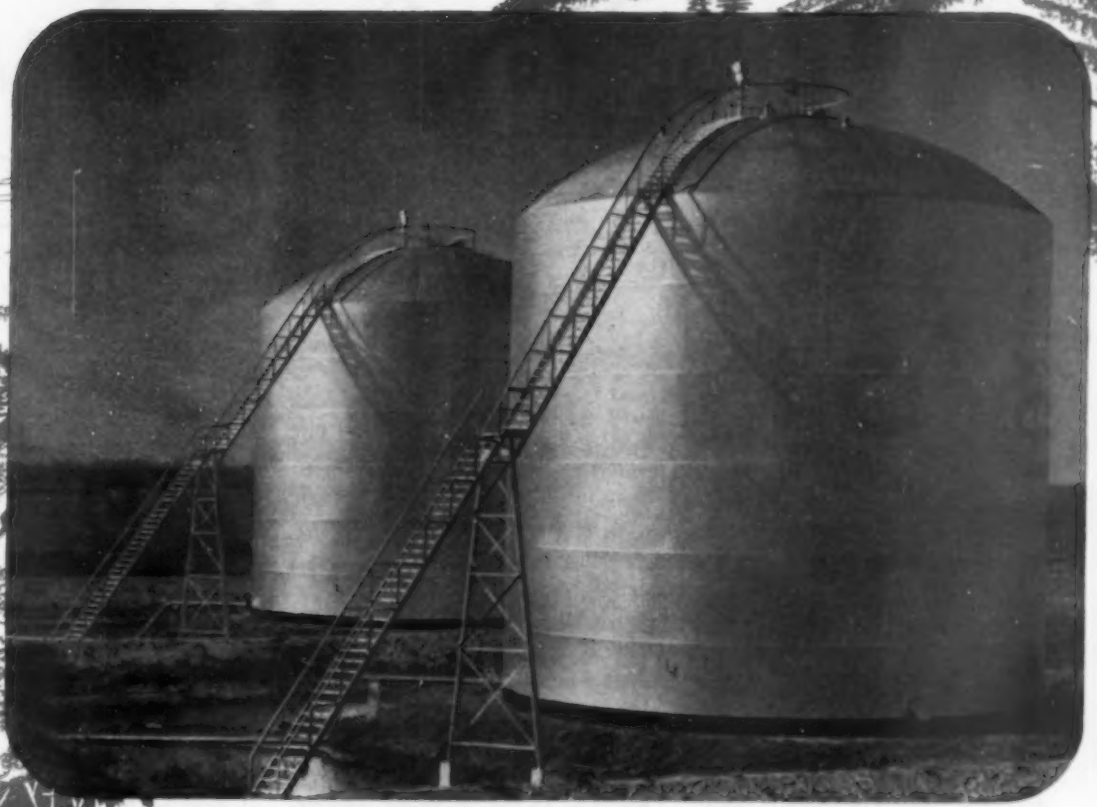
US RUBBER

Mechanical Goods Division

United States Rubber

STORAGE TIME

in the Green Mountain land



54-ft. 8-in. diam. by 48 ft. high Hemispheroids

HORTON HEMISPHEROIDS® are used for the storage of premium and regular grade gasoline at the American Oil Company Plant, Shelburne, Vermont. Here, in the land of Ethan Allen's fabled Green Mountain Boys, the two 20,000-bbl. Hemispheroids receive and store gasoline, for future local distribution, that has been produced at the company's Texas City Refinery and shipped by ocean tanker and then barge to Shelburne.

Horton Hemispheroids prevent excessive evaporation of volatile liquids as long as the internal pressure in the tank does not exceed the pressure relief settings of the valves. They are built in capacities to 30,000 bbls. and for working pressure to 5 lbs. per sq. in. in the smaller sizes.

Further information on Horton Hemispheroids may be obtained by writing our nearest office.

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IF YOU'RE IN A HOLE OVER

THICKER AND BIGGER SHELLS . . .

Kellogg's Expanded Fabricating Facilities Can Help You Out

Why let shell geometry present a production bottleneck on urgently needed heat exchangers, towers, and other pressure vessels? M. W. Kellogg's expanded and complete fabricating facilities are geared to produce shells thicker, bigger, and in shorter time than ever before.

Production tools recently installed at Kellogg's New Jersey shop to meet increasing demands for larger vessels include: a planer capable of handling steel plate 40 feet long; huge bending rolls, augmented by a new, ancillary 2,000-ton press for bending plate up to 4 inches thick; and automatic welding equipment for longitudinal seams to 16 feet in length, and circular seams 12 feet in diameter.

In heat treating, Kellogg now can handle vessels larger than a railroad car, with thirteen furnaces having temperature ranges from 1200 to 1950 deg. F. Its pipe bending facilities can shape carbon steel and alloy piping 36 inches in diameter—to exceptionally close tolerances. In nondestructive testing, Kellogg's latest addition is its Kel-Ray* Projector. Using gamma rays, this unique instrument permits the radiographic inspection of welded seams 6 in. thick, 200 ft. circumference, in a single short exposure.

Backing up Kellogg's fabricating facilities are Kellogg engineers, who can either assume entire design responsibility or work closely with your own engineers; and Kellogg's staff of fabricating-welding engineers, who plan and administer a continuing personnel training program to qualify welders and mechanics on new techniques for fabricating new materials.

We welcome the opportunity to demonstrate what Kellogg's complete engineering and expanded fabricating service can do for *you*.

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The Canadian Kellogg Company, Limited, Toronto—Kellogg International Corporation, London

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*Trademark of The M. W. Kellogg Company

The Petroleum Engineer
February, 1956

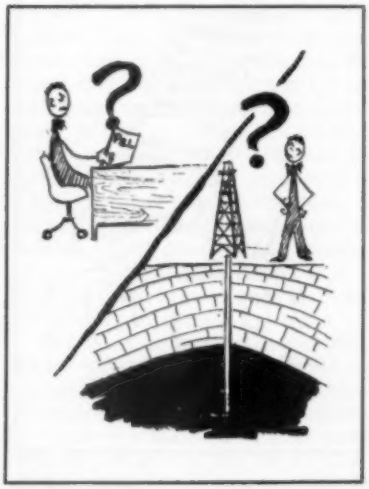
EXCLUSIVE **Accountants and engineers must work together to assure effective, accurate reports for management. It takes both professions to find**

The CALCULATED FUTURE

L. E. Frensley

PETROLEUM accounting has become as complex as petroleum engineering. There may be days when the petroleum accountant wishes he were trying to prepare a profit and loss statement for a financial institution, where his greatest headache might be estimating a reasonable allowance for uncollectible loans. But, generally, he considers matching wits against the unknowns and intangibles of "this fascinating oil game" as challenging and interesting as petroleum engineering.

As a matter of fact, there are many parallels between the principles and philosophies of the petroleum accountant and those of the petroleum engineer. We rely to such a large degree on data provided by engineers. In each case we are applying our training and experience to solve a profit-and-loss problem, while the engineer applies his training and experience to solve a production, or refining, or other technical problem. And in either case, an exactly accurate prediction is often impossible to achieve. Without the ability to *see* how much crude oil remains in an underground reservoir, or what is happening inside a cracking unit, the engineer can only estimate — on the basis of what he has learned and what he has observed happen under similar circumstances before. Since the accountant's figures are based in so many instances on the engineer's estimates, sometimes tempered by the accountant's opinion based on *his* experience or observation, they are subject to the same errors in judgment. There is no intention of undervaluing the role of either the accountant or the engineer in the petroleum industry. No business can operate successfully without experts in both fields. It simply seems desirable to remind ourselves occasionally that the ultimate value of our work depends largely on the skill and judgment with which we apply our principles and philosophies — to a far greater degree than in many other industries.



Accountants and engineers apply training and experience to solve problems.

The evolution of petroleum accounting and petroleum engineering has been so gradual, it is only possible to evaluate their development by contrasting the very rough estimates which were acceptable 50 years ago because they were the best available, with the refined calculations which are required by management today. This brings up one more general observation that should be made before we proceed to details — another parallel between accounting and engineering. The industry has become so complex that no one

The Author

L. E. Frensley was elected comptroller of the Magnolia Petroleum Company in 1950. A native of Oklahoma, he received his AB from the University of Oklahoma, where he was a member of Phi Beta Kappa and Delta Upsilon. Frensley spent four years in the foreign producing accounting department of Socony Mobil Oil Company, Inc., in South America and New York. He is an active member of the API Financial and Accounting Committee, and of the Controllers Institute of America, having been elected a national director of the Controllers Institute in 1954 and a vice president in 1955.

The petroleum industry has become so complex that both accountants and engineers have become specialists.

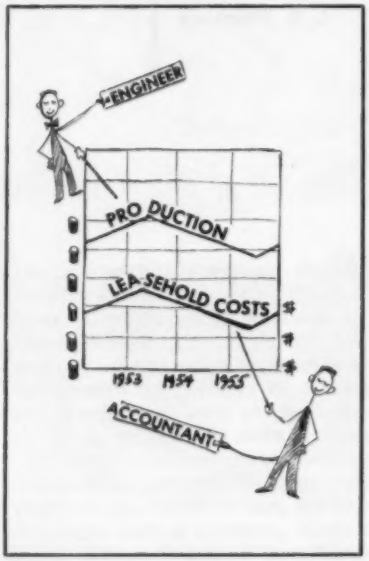
man can fairly claim to be an expert in his entire field. Aside from the specialization required by the variety of operations in an integrated company — exploration, production, transportation, refining, and marketing — accounting specialists are required in the fields of taxation, other governmental reporting, budgeting, auditing, and a variety of service functions, the latest of which is electronic data processing. And now to a brief discussion of some of these specialized fields. . . .

Production Accounting

In our company, as in many integrated oil companies, the producing accounting department is concerned with oil and gas from the original exploration work, through leasing and drilling, to eventual production. This group performs the accounting for a number of related operating departments: Land, geological, geophysical, drilling, civil engineering, petroleum engineering, natural gas and gasoline, part-interest, machine shop, and material. From the time a decision is made to send a geological or geophysical crew into a virgin area to explore for prospects, until the oil flows into the lease tanks, these accountants are concerned with recording the capital costs and operating expenses of our oil and gas properties.

When consideration is to be given to the purchase of a producing property, the petroleum engineers are first asked to furnish an estimate of the reserves. The accountants make their calculations of the capital recovery expenses and the income tax effects of the purchase and development of the property. From this information, management can evaluate the proposed purchase.

Reference to capital recovery expenses above leads to mention of one of the major tasks which accountants and engineers undertake jointly. For all producing properties, many companies use the unit-of-production method for amortizing leasehold costs and investment in certain tangible lease equipment. Included as "leasehold costs" are the lease bonus, legal and related costs incident to establishing title, and — for income tax purposes, at least — a pro rata amount of geological and geophysical exploration expenditures capitalized. Practice varies as to the items included in "tangible lease equipment." Under the unit-of-



Engineer and accountant have a joint task in many calculations such as amortization of leasehold costs.

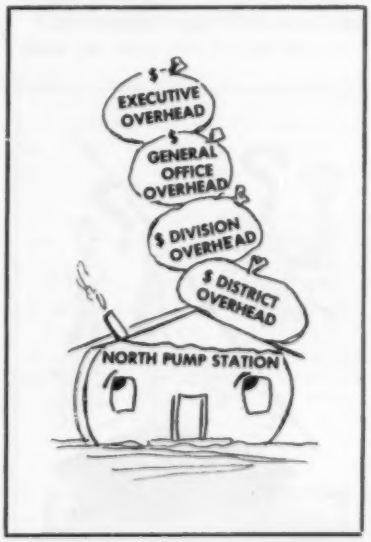
production method, the sums of both these accounts are amortized by charging to each year's expense a pro rata amount based on the ratio between total reserves and the current year's production. All of these amounts are readily obtainable from the regular financial and operating reports but they must be assembled and the calculations made by the accountants. Since the entire calculation depends on the reliability of the engineers' estimates of total reserves, we can find ourselves in pretty much of a pickle if they are not very carefully made.

So much progress has been made in improving liaison between operating people and accountants in the field of part-interest operations that it deserves mention. In the old days, requirements were included in operating agreements which seemed perfectly clear and logical to the operating men who prepared them, but were extremely difficult to carry out without radical changes in normal accounting procedures. Gradually, the approach to new joint-interest operations has come to include accountants around the conference table with operating men and engineers, and together we are framing agreements which are satisfactory as far as operations are concerned, and far easier to account for.

Pipe Line Accounting

Accounting for pipe line transportation revenues and expenses calls for close co-operation between operating personnel, engineers, and accountants. Direct expenses at each terminal and pump station, or other facility, are relatively straightforward, but the allocation of expenses applicable to various lines, or to more than one segment of a line, must be based on the judgment of operating men, the measurements of engineers, or both. The same is true, of course, for revenues; and when tremendous volumes are involved, a difference of a fraction of a penny per barrel on one side or the other may well mean the difference between profit and loss.

Studies of profitability of proposed new lines or systems require the joint efforts of engineers and accountants. Engineers' estimates of product supply and throughput are yardsticks for determining the size and type of line to be built. Historical costs of construction and operation maintained by the Accounting Department are guides for estimating similar costs of the new



Allocation of pipe line expenses must be determined by close cooperation between engineers and accountants.

line. Probable payout and estimated earnings are joint responsibilities of the engineer and the accountant.

Common carriers are subject to the jurisdiction of the Interstate Commerce Commission. Valuation reports, determination of service lives and salvage values and various other reports must be prepared and filed by the accountants. The impact on profit and loss, rate of return, etc. is significant and the efforts of both the engineers and accountants are essential if all the factors involved are properly balanced.

Refining Accounting

The intricacies of modern refining processes require skillful analyses of costs and yields. Operating costs of each unit in a refinery are collected and charged to the crude and other components processed through the unit. An accountant would be lost in this type

Narrow profit margins in marketing require close understanding between operating and accounting departments.

of work without the flow diagrams and process charts furnished by the engineers. And in spite of these aids, the impossibility of defining the exact cost of refining, processing, and blending of each of the hundreds of products which come out of our refineries has left no alternative to the practice of allocating many costs on the basis of selling prices. The problem may be likened to the situation of a butcher trying to allocate the cost of a steer to each cut of beef carved out and offered for sale to customers.

The introduction of a new product or the variation in the quantity of one or more products produced will affect throughput, type of crude, design, variation in production of other products, or a combination of two or more. Here, again, the economics of the change requires the services of both engineers and accountants.

Marketing Accounting

The intense competition among marketers is familiar to everyone who reads the advertisements in newspapers and magazines, and notices the posters displayed at service stations. Marketing operates on a very narrow margin and this makes strict classification of income and expenses especially important. Although there are circumstances and conditions peculiar to gasoline and oil selling which distinguish it from other mercantile businesses, it is still basically like other selling enterprises.

Marketing conditions do not remain static and changes affect the accounting. For example, the growth of the LPG market during the past few years has introduced new problems in production, handling, storage and distribution. Accountants must keep informed on such changes through close liaison with technical and operating departments in order to provide suitable accounting procedures and reports.

Economic Studies

We have been writing about some of the more conventional functions of the accountant. While "keeping books" for the business may be the backbone of our work, there are many other services which are equally useful. Dealing with figures every day and necessarily observing "where our income comes from and where our expenses go," we are obviously well qualified to assist in economic studies. In most companies, as in ours, accountants and engineers work together in many worthwhile surveys of this type.

Role of Taxes

The effect of income taxes on any major project has brought accountants into the picture in advance of many undertakings instead of afterward, as was sometimes the case in the past. We have been able to demonstrate that it is better to be forewarned about a tax or other accounting charge, than to learn the bitter truth after it has happened. The application of tax laws and regulations to the many types of income and deductions is based on established principles, practices, and conventions of accounting. Special statutory provisions and audit exceptions not "booked" must be taken into consideration in tax accounting. Although these exceptions are numerous, the foundation of the system still rests on the principles of accounting. This being the case, the accountant is best qualified to advise operating management as to the tax consequences of a new project or a change in operations. Since taxes take such a big bite from earnings, and since the incidence of taxes varies from one situation to

The accountant can best advise the operating management as to the tax consequences of undertaking a new project or making a change in operations.

another, sometimes it develops that the capital required for a purchase of one type might better be applied in a different manner.

Electronic Computers

And now, a few words about something you've already read and heard a great deal about — EDPM, or electronic data processing machines. In a company the size of ours, the volume of paper work, data reduction, and calculations in all departments reaches staggering proportions. Electronic calculating machines are being developed to perform many of these tasks much more easily than is possible with our present machines and methods, and with almost unbelievable speed. To mention a few examples: Manpower analyses, inventory controls, refinery scheduling, exchanger design, fluid flow, electrical circuit design, orifice plate coefficient calculations, product blending control, and such accounting applications as production and settlements for royalty and purchases of oil and gas, payroll, labor and material distribution, sales analyses and receivables, proration of indirect costs, and material accounting and purchasing.

Studies of this advanced equipment have been under way by our company for some time and have already led to the installation of intermediate-size computers to handle research, engineering, and accounting problems. Plans are being made to extend the use of this equipment to other work, but considerable work is required between the time a decision is made to try a new field and the completion of a schedule or "program" for the problem.

The results on the work we have transferred already to these machines are up to our expectations, and the prospects for other problems still in the planning stage appear very promising. Throughout all our planning, we have kept in mind the general principle that the transfer of work to elec-

tronic machines should be justified by the economies effected. It is recognized, however, that there are supplemental advantages in securing information faster, in securing more thorough analyses of problems, or in exploring certain phases of our operations which it has been impractical or uneconomical to tackle heretofore.

The transfer of work from manual or tabulated procedures to electronic procedures has involved reviews of the methods by which many of our statements are produced and the processes by which our accounting is carried on. These surveys have proved to be helpful from the standpoint of simplifying many of our routines and reducing the steps involved, without impairing the results in any way. In these reviews, we have sometimes started at the end and worked backward. Knowing what information was required and what data was available from which the results might be calculated, we have developed "programs" for the step-by-step utilization and integration of the data, and the necessary computations.

Depreciation Calculations

In all the phases of the oil business, and in all the departments we have been writing about, accountants depend on engineers in determining estimates of useful service lives of property, on which to base depreciation calculations.

The distinction between the classes of items which are charged currently to expense and those whose cost is recovered over a period of years through depreciation is fairly well understood. Sometimes we find that the mechanics of depreciation calculations are not so clearly known outside the accounting offices. An example can illustrate the complications.

Assume equipment purchased in 1950 for $1,000,000, with a useful service life originally estimated at ten years. By 1955, half of the cost will have been charged off, leaving $500,000 to be recovered during the remaining five years.

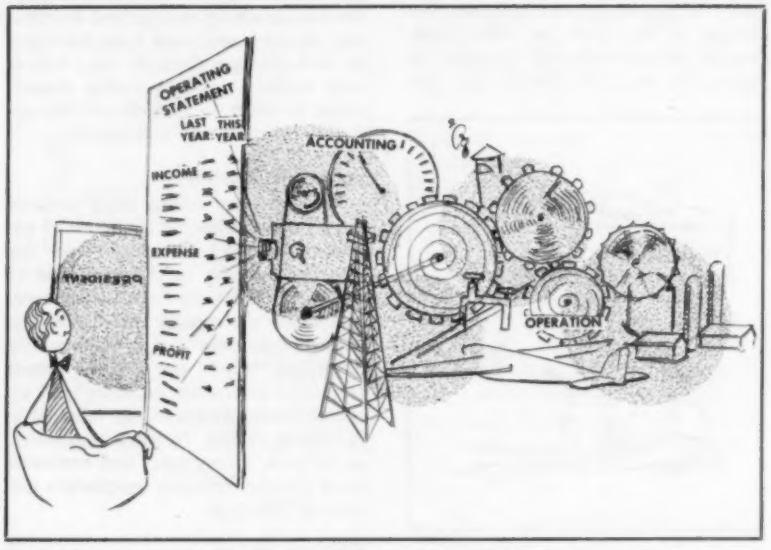
If the engineers or other operating people decide at this point that their original estimate was too liberal, and that the remaining useful life will be only two years instead of five, 1956 and 1957 will be burdened with a charge of $250,000 each year, instead of $100,000 as originally contemplated. These are significant differences and, aside from the prospect of reduced profits during the next two years the picture is darkened by the realization that profits during the previous five years, have been correspondingly overstated. Thus, although there might have appeared to be relatively little difference between initial estimates of seven years or ten years, the fact that the revision was delayed points up the difficulty.

Lest there be any temptation to further delay admitting an error in judgment in such cases, let it be pointed out that if the engineer or operating man simply keeps quiet, suggesting no revision at all, then in 1957 when the equipment is finally junked or sold for scrap, the shock of a $400,000 charge-off in that year will be all the greater.

Research, engineering, accounting and other problems can be quickly solved by EDPM.

Improvement in Communication

In some instances accountants have difficulty in ascertaining exactly what information or what results are required. The increasing complexities of business mean that management must give more careful consideration to their requirements for information from accountants, as well as from engineers. We often hear the complaint, "We can't tell anything about this statement; why don't you accountants give us a report we can understand!" Doubtless, engineers often hear the same complaints about their own reports. Modern accountants generally are keenly aware of the need for intelligible reports and are willing and ready to provide them if the managers will take sufficient time to tell them more clearly what they want to know. Much has been written during the past several years about the unfavorable ratio between production workers and clerical employees. A considerable portion of the increase in accounting and clerical work is rightfully attributable to additional tax and other governmental reporting requirements. A further increase has been due to the need for more reports resulting from complexities of modern business. No longer can a "boss" know everything about the business without depending upon specialists to whom responsibilities are delegated. Accordingly new reports and statements of various kinds are now needed to measure performance. Despite the need for more statements generally, the elimination of a sizable fraction of our paper work could be accomplished if each executive would analyze periodically his requirements for facts and figures and cut out the obsolete and superfluous reports. That would save money for the company and permit more effective concentration by both accountants and engineers in making the gears mesh in *"the calculated future."* ★ ★ ★



More informative and more accurate data will be available to management when engineers and accountants have a better understanding of what is required.

Trainee John A. Chisholm, geological graduate from the University of Oklahoma, brings a U. S. import-export chart up to date in the Economics and Planning Department at Bartlesville.

Trainee James R. Adams, electrical engineer from the University of Oklahoma, on regular assignment in the Treasurer's Division at Bartlesville, studies the cashiering operations of the company.

Of top importance to business,
good management is also scarce . . .
Cities Service has been growing its own
for a half century . . . This is one way to make an

$ $

Investment in Management

Ernestine Adams*

YOU don't often find a geologist in a refinery nor an electrical engineer in the treasurer's office — except at Cities Service Oil Company.

There's a chemical engineer on a waterflood project in East Kansas and a political science major gaging tanks at Oklahoma City. Sounds like an army snafu. But it isn't. It's the engineering training school — a system established more than 50 years ago by Henry L. Doherty, one of the geniuses of the oil industry. So far as we know, it was the first comprehensive training program set up by any company in the oil or gas industries.

The young graduates selected for the program are the capital investment of the company in future management. They are the executives and administration officers who will guide the company's progress tomorrow.

This plan has been so successful with Cities Service Oil Company that almost all of its directors are graduates of the course. S. B. Irelan, president, was in the "Junior Engineering Program" in 1909.

The young trainee sees the way he is headed and former graduates of the plan in top management are living proof that the program is a good map for a successful career.

Because it has worked so well for so long, the organization of the system will be of interest to other companies, whether they now have a training program or not. Other firms have already set up similar training courses after studying Cities Service's program.

Perhaps the keys to the success of Cities Service's development program are these factors:

1. **There are no classes.**
2. **There is no set time to start or stop.**
3. **The training is on a completely individual basis.**
4. **The trainee learns by doing, from on-the-scene observation and from the recounted experience of those with whom he comes in contact.**
5. **The trainee is assigned to a supervisor in each of the various training assignments and he benefits from the counsel and experience of these long-time supervisors.**
6. **The training program brings into focus what the trainee is best suited for and most capable of doing.**
7. **The program minimizes misplacement of college-trained employees.**
8. **The program is completely flexible. It can be adjusted to provide maximum benefits for virtually all types of college graduates needed in company operations.**
9. **Although counselors encourage trainees to complete the full training, trainee may stop his training to accept a permanent job offered him in any of the company's operating divisions or service departments.**
10. **Training prepares the trainee for his first permanent job and provides the impetus for early and subsequent progress and advancement.**
11. **Top management of the company offers a constant example of the fact that the training is worth having.**

*Management Editor.

Political science major from The Citadel, Thomas F. McGarery, on training assignment with the Production Division at Oil Hill, East Kansas, is analyzing water with Roy Curry, company chemist.

With Milford Piper, foreman of water-flood plants, and Larry Wigger, production engineer, McGarey takes a sonolog reading to determine fluid level on a pumping well on the Kirkpatrick lease.

Selection

The first move, of course, is selection of graduates to take the training. This begins the same way most companies get their graduates — by interviews scheduled at universities and colleges in the areas of company operations. These are handled by the Industrial Relations Division, which supervises the program. The interviews are held in the fall and spring before graduation and require about 20 minutes time for each interview.

Not all those interviewed are considered for the training program. Some are employed for a particular job.

The company is more interested in a well-rounded person with good basic education for the training course than it is in the particular degree the graduate will receive. Petroleum, mechanical, civil, chemical, electrical, industrial and geological engineers are sought as trainees along with geologists and geophysicists. These are engineer trainees. There are also business trainees with business administration, accounting, economics, political science, marketing and other majors.

The near-graduate is asked to fill out an application and provide a personal photo and a transcript of his courses and grades. The applicant's military status is considered, but military liability is no deterrent to his enlistment in the training program.

If he is considered a good prospect, he is invited to Bartlesville, Oklahoma, headquarters of Cities Service Oil Company, where he is quickly plunged into one important business experience — meeting people. He is taken around the offices to talk with 12 to 15 key men, including vice presidents — all in one day. He is given as sharp a picture as possible of the employee development program and what it will mean to him.

The men who interview the prospect must be unanimous in their opinion that he is good management material. When they agree in his favor and his references and school record hold up to the standard required, he is invited to join the company and take the training. If the graduate is married, an interview with both husband and wife is arranged, either before the graduate joins the training course or during his early training.

Considering the importance of the decision since it is a lifetime proposition, the company gets a high percentage of acceptances. Over the last three years when engineers have been scarce and competition for them has been heavy, more than 50 per cent of those who pass the early tests decided to join Cities Service Oil Company.

INDUCTION CHECK LIST
Trainees

Name_____ Date_____ Degree_____

Please initial each item. Do not merely check.

_____ Inform as to reporting place.

_____ Date to report agreed upon. Date_____.

_____ Arrange for physical examination. (For Engineers and other Technical Trainees only.)

_____ Date_____. Time_____. Place_____.

_____ Fill in apartment schedule if married.

_____ Duplicate application for employment on file.

_____ Empire news sheet form received. (Mail to Publications, Room 101).

_____ Completed and signed employment card received.

_____ Income tax withholding form received. (Route with employment card.)

_____ Signed Patent Agreement received. (2 copies.) (Engineers and other Technical employees only.)

_____ Payroll procedure (including time sheets for Accountants, Business grads., etc.), hours of work, vacations, and holidays explained.

_____ Credit card explained. (Application card should be obtained, approved, and mailed to Cashier and Credit Dept.)

_____ Explain Group Insurance and supply booklet and application card. (Completed and signed card to be mailed to Payroll Department.)

_____ Doherty Men's Fraternity and other social and sports activities explained.

_____ Furnish with Doherty Men's Fraternity application card. (Deliver completed and signed card to executive secretary.)

_____ Retirement and Thrift Plans explained. Explain available auto insurance.

_____ Explain Empire and Service magazines.

_____ Extend invitation for counsel on all problems.

_____ Refer to rooming house if single and allow time to get settled.

_____ Reported for physical.

_____ Results of physical checked OK_____. NO_____.

_____ Check military status. Note in file and on training schedule.

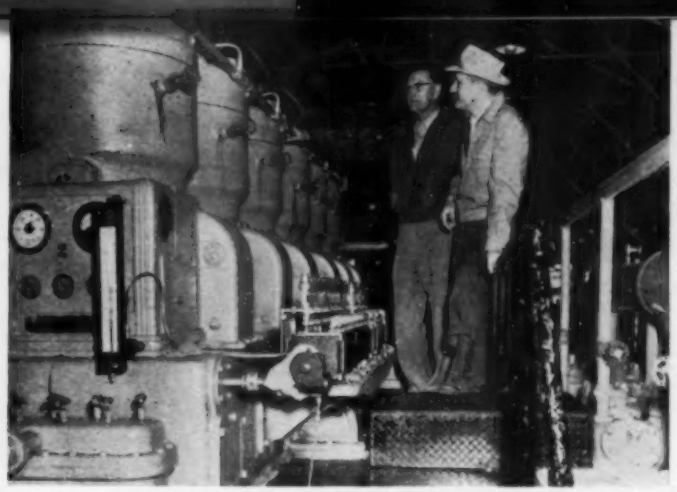
_____ Schedule training assignments. (Check with Department Head in charge of first assignment.)

_____ Explain details for traveling expense statements and furnish trainee with several blanks.

_____ Issue one 6015½ memo cover with filler sheets 6105F, and one 8½ x 11 looseleaf notebook 8626-1 or 20141. (Phone 288 to replenish supplies.)

_____ Issue organization charts.

_____ Send or take trainee to first assignment.



Operation of the 600 hp compressor is explained to the trainee, D. L. Hintermeister, by Plant Superintendent Charles Powell. A chemical engineering graduate from Iowa State, he was on assignment at the Cities Service Natural Gasoline Plant near Pampa, Texas.

After giving Trainee Hintermeister an over-all explanation of gasoline extraction, Powell explains instrumentation. Hintermeister takes notes on the function of continuous recording instruments to control process variables in the still area.

Characteristics of Applicants

Approximately half of the new trainees are married. Wives and children, too, join the men. Cities Service has leased some furnished apartments in Bartlesville so the new employees are assured housing during their assignments at the home office. They pay rent at a rate below cost to the company. The company pays expense of moving about during the training period. Bachelors are established in rooming and boarding places. This arrangement has helped trainees get acquainted with each other, and they feel more at home when others in the same circumstances are neighbors.

The company is deeply interested in a man's family. While he is learning and deciding what he wants to do, his wife is also learning about his job and helping him come to a decision about his place in the company. When the trainee is moved, his family goes with him.

Induction

After the decision to take the Employee Development course has been made, a form called the "Induction Check List" is filled out for the trainee. He is given a place and a date for reporting to begin his training. Arrangements are made for a physical examination, for housing, for news releases to company magazines, his alumni publications and home town newspapers, for membership in Doherty Men's Fraternity, for income tax withholding, and for training assignments.

The trainee has such things explained to him as payroll procedures, hours of work, vacations, traveling expense, group insurance, social and sports activity, retirement and thrift plans, and company organization. He is given a loose leaf notebook for notes on his assignments, and is placed on the list to receive company magazines.

Schedule

Now the trainee is taken or sent to his first assignment. For the engineer, this can mean 41 weeks of training with some time spent in each department. The business training program runs 25 weeks. He stays long enough to get a good grasp of the operation and function of each division, which added together make up the progress of a company.

Geological trainees may take the entire basic training or they may be transferred to the company's Land-Geological Division for more specialized training. This training includes assignments in land-leasing, seismic exploration, geological scouting and in field and office geological work.

Sales training may include all or part of the basic training, with specialized training by Marketing Division personnel in the field of supply, distribution, sales and cost accounting, lubrication and industrial engineering. Included is point-of-sale training at retail, industrial, agricultural, and fleet levels.

The basic course includes:

Basic course	Field weeks	Office weeks	Total weeks
Treasurer's and budgets	—	4	4
Purchasing and stores	—	2	2
Industrial relations	—	2	2
Engineering	—	2	2
Economics and planning	—	1	1
Production	8	2	10
Pipe line transportation and supply	4	2	6
Manufacturing	6	2	8
Natural gasoline	4	2	6
	22	19	41

Alternate assignments

Marketing	4 weeks*
Land-lease	2 weeks*

* Or to suit trainee's needs.

Assignments usually follow in the above sequence, the first ones being in the general office. But, in order to avoid an oversupply of trainees in any one department it is necessary sometimes to deviate from the schedule. There can only be one or two trainees in a department at a time because of the amount of individual instruction given each one.

Usually field work in one division is followed by office work in the same division so that the connection between the two operations is understood while it is fresh in the trainee's mind.

Assignments

At the beginning of each assignment, the trainee is supplied with an outline of what he should look for. Appropriate reading material and reference data are made available to compose a factual background of that particular operation. This material is for the trainee's use if he wants it, but its use is not a requirement.

The programs for each division are excellent outlines of work done in that part of the company. For instance, in the production division the field assignment is five weeks in a roustabout gang and three weeks of field engineering, office and development work.

Then the Bartlesville office assignment includes 8 days at reservoir engineering and the remainder of the time devoted to secondary recovery, general records, contracts and payroll accounting, construction requisitions and job orders, and to the economics section.

Trainees are assigned to certain supervisory employees for each assignment. The supervisors themselves come under constant check so that the young engineers get the best possible instruction and counseling. Supervisors are advised to make every effort to see that trainees witness any work of particular interest and to revise schedules to meet the needs of individual trainees.

After each assignment, the engineer returns to headquarters and submits a written report of his work. His supervisor for the assignment sends in a rating form, like the one shown, to cover the period. These reports go to the

Trainee Joe P. Green, geological engineer from Missouri School of Mines, watches Station Gauger Dean Newlin as he gauges an 80,000 barrel tank and explains the fundamentals of crude oil storage.

Field Gauger Jack Lyle accompanies Trainee Green on a gauging assignment in the Oklahoma City field where Green is on assignment with Cities Service Pipe Line Company.

division management and industrial relations department. The trainee's report is judged by its ease of expression, spelling, sentence construction and content; it is checked by the division. The supervisor's report is discussed with the trainee and suggestions made for improvement. This constant reviewing and refreshing on the subject of training keeps the purpose firmly before the trainee. He should have an understanding of the function of the department to which he was assigned. He has been employed for training and not for a specific job so, his job is learning.

When the trainee is on the job, he may be visited by a personnel man for counseling and encouragement. The company is selling its organization to the trainee at the same time he is selling himself to the company.

There are weekly meetings of trainees in the home office for those who can attend. These last about an hour and have from 6 to 15 trainees in a round table discussion of their experiences. Frequently key employees in the company are brought in for question-answer sessions.

First there are announcements, and then each is asked to tell what he is doing. He learns to express himself, and the others learn something about a division where they may go later.

A monthly report goes to all divisions from the Industrial Relations De-

TRAINEE PROGRESS REPORT

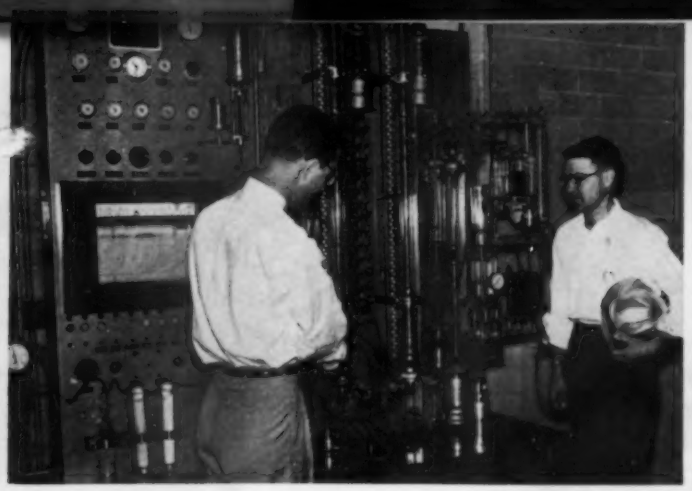
NAME_____ RATING_____

DIVISION_____ RATING SUPERVISOR_____

In Consultation With_____

Consider only one trait or quality at a time. Do not let your judgement concerning one trait influence your judgement on the other traits. Consider the individual's entire work performance. Do not base your judgement on only one or two occurrences.

COMMON SENSE: Consider his ability to reason, to think logically and to come to logical conclusions.	With regard to this characteristic, the trainee is: Outstanding___, Superior___, Average___, Below Average___, compared to all other trainees rated. Remarks:_____
JOB PERFORMANCE: Consider his ability to analyze problems, learn new duties, to make suggestions, and dependability.	With regard to this characteristic, the trainee is: Outstanding___, Superior___, Average___, Below Average___, compared to all other trainees rated. Remarks:_____
PERSONALITY AND APPEARANCE: What effect did he have on you? Others? Did he get along well with supervisors, employees? Please comment.	With regard to this characteristic, the trainee is: Outstanding___, Superior___, Average___, Below Average___. Remarks:_____
LEADERSHIP: Based on your experience with the trainee, do you feel that he could develop managerial qualities?	With regard to this characteristic, the trainee is: Outstanding___, Superior___, Average___, Below Average___. Remarks:_____
TOTAL IMPRESSION: What type of employee do you think he will develop into? What is his potentiality?	Outstanding___, Superior___, Average___, Below Average___. Remarks:_____



Civil engineering graduate from Kansas State, Trainee Charles Brunnert, on assignment at the Cities Service Refinery at Ponca City, Oklahoma. Resident Chemist Dale Godfrey, left, demonstrates use of Podbielniak electronic analyzer in process control.

Trainee O. W. Shumate, business administration graduate from Oklahoma University, at the Cities Service compound plant at Cicero, Illinois, where Supervisor R. W. Whitmore explains detailed workings of a can-filling and sealing machine.

Buyer Homer Roswell, right, meets Trainee John A. Chisholm, Oklahoma University geology graduate, at the beginning of his purchasing assignment and presents the purchasing needs of the fully-integrated company.

Trainee Mark Gingrich, civil engineering graduate from Purdue, on regular assignment in the Chicago Marketing Division. Here he is taught the proper pump island procedure for servicing customer cars.

partment giving a list of the trainees currently on the program, the degree and school of each, when employed, his current assignment and the next two assignments to be arranged.

Permanent Placement

Sometimes a trainee gets to a department when he is half way through the course and decides that's the place for him; no other job will do. If the management of that division agrees, he is taken on permanently and does not finish the training program. Any time a trainee is offered a permanent job he wants to take, he is free to do so. All trainees, however, are encouraged to complete all phases of the course to obtain the maximum benefits. Permanent assignment is the result of mutual agreement between division management and the trainee.

Those who complete the 41-week course usually have decided where they want to go to work, and the decision usually is agreeable to the division. There is often considerable competition among departments for the graduate of the training program. Some trainees who have finished the course have been wanted by practically every division.

It is long training — 41 weeks — longer than a full two terms in college or university and some are impatient to get along in their specialty.

When a trainee has finished the program, however, he has a broader view of the industry and the company than he could ever get any other way in so brief a period.

One of the basic accomplishments of the training course is that it minimizes misplacement of personnel. After sampling a great variety of job assignments in each of the company's integrated operations, the trainee knows just where he fits. As many as half of the trainees who joined the course with a preconceived idea of the job they were training for, changed their minds as they progressed through the course.

The trainee's salary is paid during this learning period and moving expenses are also paid by the company.

The importance management attaches to the program is hardly measured, however, by this dollar-and-cents angle; the effort of experienced men devoted to planning the course and to instructing the trainees and the time of top management set aside for interviewing and counseling these young engineers is probably a greater contribution to the development program than money. It is understandable that since more than 600 trainees have gone through the course over the years, many management and supervisory positions are filled by those who graduated from the training course.

One Cities Service executive says, "The young graduate training is as good as a master's degree and you are paid for taking it." ★ ★ ★

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services for the oil industry DOWELL

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How to Get the Best Results From RESEARCH

C. G. Williams

THE oil industry invests heavily in research. The bulk of it is, of course, carried out in the United States where 60 per cent of the tonnage of the world's oil products are sold. The estimated expenditure in the United States was $100,000,000 per annum in 1951[1], while a probable figure for the U.K. is £2,000,000 per annum. Such figures, while large, are not unduly large in relation to the magnitude of the oil industry. It is customary to express research expenditure as a percentage of the gross turnover of a company or industry, and the figure for the U. S. oil industry is approximately 0.6 per cent. For comparison, a typical figure for the chemical industry lies between 2 per cent and 3 per cent, and there are other industries that spend even more in relation to their sales, though in such cases there is often a strong element of government support.

There are other industries, on the other hand, that spend less. The OEEC has recently published[2] figures of "national civilian research budgets" in which research expenditure is expressed as a percentage of gross national product. The figure for both the U. S. and the U. K. is 0.5 per cent — so that the petroleum industry is close to the average.

Such percentage figures are the net result of a large number of factors such as:—

1. **Scope or need for research, that is,** whether it is possible, practicable, or desirable, to make improvements in a given field. For example, the scope is likely to be greater for motor gasoline than for fuel oil and greater for chemicals than for gasoline. An important factor here is the "newness" of a field and whether the market is an expanding one. Again, questions of the profitability of the product are obviously relevant.
2. **Number of research ideas: The** larger the number, the greater the possible expenditure on simultaneous or consecutive lines of investigation. On the other hand, while the need may be great, the number of ideas may be all too small.
3. **Availability of finance, both operating** and capital, for expenditure on laboratories.
4. **Similarly, availability of finance** for implementing the results of research — in terms of plant and equipment, operating costs, marketing costs, etc. For example, it is possible to envisage projects arising from research having to be shelved because of insufficient capital. It has been stated that the ratio of expenditures on research, development, and manufacturing plant for a given project is 1:10:100.
5. **Availability of scientific manpower** suitable for research and for implementing the results of research. This has become a very important limiting factor due to present supply not meeting demand. A correct balance has to be maintained between manpower used for research itself and manpower required to ensure full use of research results.
6. **The general competitive situation.**
7. **Amount invested in research and** development by other industries, which may tend to set the pace for the oil industry, such as the automobile industry. Development of new equipment or appliances may require new oil products, such as special fuels and lubricants for jet aircraft. Failure of an engineering industry to tackle its own developments adequately may also put an additional research load on the oil industry, which has then to develop products unnecessarily "special."
8. **The "expensiveness" of a given** field of research. Certain kinds of research are relatively cheap, but where costly engine tests, pilot plant studies or special analytical techniques are required, the expense is correspondingly inflated.

Each of the above factors should be weighed in considering the intensity of effort to be devoted to a particular field of research. Failure to do so may result in misguided or wasted effort.

Pure, Applied and Applicational Research

Research can be defined as the use of scientific methods for making new discoveries and a distinction is usually drawn between "pure" research and "applied" research. In general, most pure research is carried out at universities and is concerned with knowledge for its own sake. The kind of research carried out by the oil industry is, of course, mainly "applied," that is, directed towards some known objective.

It is important to recognize the indebtedness of industrial or applied research to pure research.

Applied research is, to a certain extent, carried out in "commercial blinkers," and pure research, with no such blinkers, can frequently suggest an entirely new route. It can also help in providing new techniques of analysis, etc., that can become very important tools in applied research. Finally, industrial research is dependent on a supply of scientists trained, to a large extent, in postgraduate schools devoted to pure research in our universities.

Accepting, therefore, that applied research is the main category of re-

[1]Editor's note: This figure for 1955 is estimated at more than $250,000,000.
[2]OEEC Report on the Organization of Applied Research.

The Author

Dr. C. G. Williams is a director and general manager of Shell Research, Ltd., in the United Kingdom. After taking degrees in engineering at London and Manchester Universities, he was, from 1923 to 1930, a research engineer on the staff of the first co-operative research association formed for the motor industry. This was later to become the research department of the Institution of Automobile Engineers, of which Dr. Williams was made director of research in 1934. He was responsible for the acquisition of the IAE Laboratories at Brentford, and was personally associated with a number of investigations, such as the corrosion aspects of cylinder wear, exhaust valve life, bearing temperatures, crankshaft fatigue and brake friction and durability. He obtained his DSc (Eng.) degree in 1941.

In 1940 he joined Shell as director of research of Aero Engine Laboratory at Thornton. During World War II this laboratory operated for the Ministry of Aircraft Production on various problems concerned with aviation fuels and lubricants. After the war Dr. Williams became first director of engine research and in 1948 director of research for the whole center. Since 1952, he has been in the Shell London office, where he continues to be responsible not only for Thornton Research Center, but also for Shell's Agricultural Chemical Laboratory at Woodstock.

search carried out by the oil industry (as well as by other industries), it is perhaps time to explain what is meant by "applicat onal" research.

Operations of an oil company can, for convenience, be divided under the following headings:

(a) Exploration and production; (b) manufacture; (c) transportation and storage, and (d) marketing.

There are, corresponding to the above, similar divisions possible in regard to the research effort.

Exploration research embraces the geophysical and geological studies concerned with the discovery of oil, while production research is concerned with the problems of drilling and of bringing oil to the surface as effectively and as cheaply as possible.

Corresponding to manufacture there is "process research," in which one is attempting to develop new processes or improvements in existing processes that will give, for example, a greater yield of useful products, reduce manufacturing costs, etc. In addition, there are problems of refinery engineering and of instrumentation.

Transportation and storage of products may give rise to their own range of problems that require investigation. These may relate to problems of corrosion of equipment, and contamination and deterioration of products, etc.

Finally, corresponding to marketing, we have the field of "applicational research," which is concerned with the whole subject of product performance and the development of products suitable for a given "application." Research is here closest to the user or customer and, therefore, to the sales side of the business. It is also close to the manufacturing side since to improve a product some change in manufacturing procedure is usually necessary.

In general, applicational research begins and ends in the field. It begins in the field because it is there that the need arises and the performance requirements are set. It ends there because the results of successful applicational research are used in the field.

Good applicational research cannot, therefore, begin until there is a proper appreciation of the nature of the problems in the field, and this may frequently necessitate personal contact of the laboratory research worker with the field. For example, if "deposits" are stated to be giving trouble in some particular application, the research worker should have the opportunity of inspecting such deposits in situ; he should ascertain from the operators of the equipment the precise conditions of use and should be able to take away for analysis samples of the deposits.

Product Performance Criteria

In general, product performance factors selected for study are those that are known to be important, that may have actually given trouble in service, and that appear capable of improvement. The oil industry — with the exception of the rapidly developing field of chemicals from petroleum — is predominantly concerned with the production of energy, and it is possible to express, in general terms, the performance criteria that dominate most applicational studies. They are: *Stability, deposits, durability, starting-up, power and efficiency*. These criteria determine, to a large extent, "customer satisfaction," and the following brief notes explain what is meant by them:

Stability. A product, while being stored or transported, should not undergo changes that would affect the performance in the final appliance. Such changes may result from oxidation, polymerization, and other chemical and physical effects, which are, therefore, often involved in applicational research.

Deposits. Deposits of one kind or another constitute one of the main performance factors of fuels and lubricants. Deposits of carbon and of lead compounds in the combustion chamber of petrol engines, deposits on injector nozzles of diesel engines and on atomizers of gas turbines, deposits in piston-ring grooves, on piston surfaces, on crankcase walls, in oil sumps, in oil-ways, in carburetors, inlet pipes, on inlet valves and exhaust valves — such deposits, if they are excessive or of the wrong kind, can become limiting factors in the performance of an engine.

In boiler plant, deposits may also cause corrosion troubles and interfere with heat transfer, and in the gas turbine, they may cause difficulties with turbine blades. An understanding of how such deposits are formed, the development of analytical techniques for their examination, and product development to minimize their occurrence are, therefore, an important aspect of applicational research.

Durability. An extended useful life and comparative freedom from the need to effect repairs of an appliance is another criterion of satisfactory product performance. This, in some respects, may be related to the preceding paragraph on "deposits," some of which affect durability. Durability may also include problems of wear and of breakdown of lubrication, such as wear of cylinder and piston rings, of bearings, and crankshaft, the transmission may introduce problems not only of wear, but also of lubrication breakdown, resulting in such phenomena as scuffing.

Starting Up. A product may frequently be judged by the ease or otherwise with which the appliance or power unit can be got under way. In this fashion are introduced problems of fuel volatility, ignition quality, lubricant viscosity, etc.

Power. The main contribution applicational research can make in the power field is to develop fuels and lubricants that permit maximum power, if necessary, for prolonged periods. The route to be followed obviously varies with the application. In the diesel engine, it is probable that the lubricant rather than the fuel is the limiting factor and in the petrol engine antiknock quality is of primary importance.

There is, in addition, a field of research that is concerned with reducing power losses; such losses may result from deposits — mentioned earlier — that cause plug fouling, pre-ignition, etc., or losses that may be reduced by lowering engine friction.

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Efficiency. Under this heading falls not only the cost of the product to the customer, but also its cost to the manufacturer. It is obviously desirable, in both cases, that the product should be as cheap as possible, and, in addition, that its utilization should be efficient. For example, anti-knock quality of gasoline affects the attainable efficiency of utilization. Similarly, any reduction in losses, such as those mentioned in the previous paragraph, helps to improve the efficiency of utilization.

The above brief discussion of performance problems and requirements is given merely to illustrate the wide scope of applicational research. There are many other illustrations that could be given; for example, there are many problems concerned with special requirements, such as in the aviation field where extremes of temperature both for fuels and lubricants are involved.

Other Objectives

It is necessary to point out that research is sometimes carried out with the object, not of improving or cheapening a product, but of maintaining existing product quality. The oil industry is based on a raw material that varies in different parts of the world, and, even from the same well, crude oil may change considerably in composition during the lifetime of the well. It is, therefore, necessary to watch product performance very carefully to ensure that changes in crude do not result in changes in product quality. This may, of course, involve studies of process variables outside the scope of this paper, but product performance is the final criterion.

Not only are there changes in crude that may affect product performance, but also changes in refinery scheduling. A refinery is a very flexible manufacturing machine producing a very wide range of products. The quantity and properties of one product may have to be varied for manufacturing or marketing reasons, thereby possibly affecting the properties of the other products.

Another objective of applicational research is what might be described as the better use of products. On the assumption that customer satisfaction is one of the main objectives of applicational research, it frequently happens that the customer may blame the oil product, even though the deficiency is the fault of the appliance that he is manufacturing or operating. This can be expressed in a different fashion by saying that if customer satisfaction can be increased by better performance, then the market for the oil product may be extended, whether that improvement has been effected through the oil product, or through the appliance, or by a combination of both.

Another type of applicational research is concerned with developing or encouraging a market for a new product or for a product that is "long." A new product happens rather infrequently these days, except in the field of chemical products made from petroleum. Uses for all the various products that are derived from a barrel of crude have been developed, ranging from liquid petroleum gas at the top, to bitumen at the bottom. There may, however, be circumstances leading to a surplus, or potential surplus, of one particular component or fraction, and an applicational laboratory may be called upon to help develop or extend the market by developing uses. This has been done, in the past, for middle distillates, wax and bitumen.

Finally, it should always be an important objective of applicational — as of other kinds of research — to increase background knowledge even though it may not appear to have any immediate application. The most satisfactory solution to a problem — and sometimes the quickest — is achieved by a real understanding of the factors involved. A good deal of such work is published and thus serves "To contribute to the common store of technical knowledge, with the ultimate motive of increased markets through better standards of living."

Research is needed just to maintain quality and to hold consumer approval

Test Methods

Studies of the kind described above obviously require laboratory test techniques in which it is hoped the essential conditions determining product performance have been reproduced. This is frequently the most difficult aspect of applicational research and the one involving the largest number of pitfalls for the unwary.

Ideally, before any laboratory studies are carried out, all the factors controlling product performance and their relative importance should have been determined. To do this completely is usually impracticable, mainly because there is not enough opportunity, time or money. All the same, one very important ingredient in successful applicational research is a preliminary study of field conditions. If the objective is to develop a lubricant or a fuel that has to withstand certain extremes of temperature, one should at least know what those extremes are. If an improved test for anti-knock qualities is required, one should know what conditions of mixture strength, power output, speed, engine temperature, and so on, should be simulated. If, in addition, new requirements are involved, they should be specified and their significance to the customer understood.

On the assumption that something, at least, is known of the end-use and of the conditions of usage of the product the problem is transferred to the laboratory, which is then faced with the task of developing a new or improved product. For this purpose, laboratory test methods are required, and applicational research involves, initially, the use of these test methods to develop products that show improved performance in the laboratory. At a given stage, such products can be subjected to field trials to ascertain whether the desired objective has been achieved, and ultimately manufacturing and marketing take over the new or improved product.

It has already been pointed out that in translating field data into the laboratory, risks are usually taken because of the inadequacy of information, and this may lead to certain false assumptions.

The first may be an oversimplification of the variables involved. Necessarily, a laboratory technique is used under controlled conditions, and certain assumptions are made regarding the essential factors that are of most importance. Here mistakes can be made through lack of knowledge.

There was, for example, a time when it was assumed that the most important requirement of an engine lubricant was to resist oxidation, and various test methods were developed to measure this property. As knowledge grew, it was realized that oxidation involved certain catalytic effects, and catalysts were therefore, introduced into the oxidation experiments. These catalysts became more and more complicated as more became known regarding the catalytic influences present in an engine.

All this work, interesting and useful though it was, missed the essential complicating factor that the most important deteriorating influences to which a lubricant is subjected in an engine originate, not from oxidation phenomena, but from contaminating influences from the fuel and its combustion products.

Laboratory techniques were, therefore, developed for measuring properties such as "detergency"; then there

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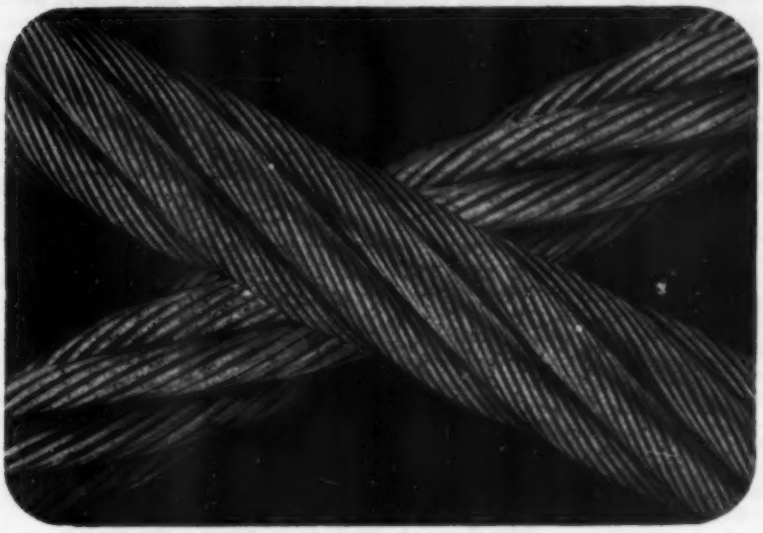

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was a realization of the important part that basicity in a lubricant could play in neutralizing corrosive products originating from the fuel, and so on. This work emphasized the misleading conclusions that could be arrived at as a result of oversimplification of test methods.

Development of the F1, F2, F3 and F4 knock test methods is a good example of the amount of effort devoted to simulating certain essential conditions occurring in different types of engines under various conditions. The F1, F2 and F3 take care of three different degrees of "engine severity," the first two in automotive engines and the third in aviation, while the F4 is intended to represent rich mixture take-off conditions in aero engines.

That none of these tests is entirely satisfactory, in terms of correlation with conditions in the field, is illustrated by the continuing work relating F1 and F2 ratings to the performance of fuels in average automobiles on the road.

It is, therefore, very important in the development of test techniques to recognize what simplifications have been made and to be ready to abandon such simplifications when further knowledge shows this to be necessary.

Another trap into which the experimenter may fall all too readily in developing his test methods is to aggravate or accentuate certain conditions that will give him quick results. This is understandable. The normal life of the product or the appliance using the product may be very large and the experimenter cannot afford the time or the money to study the problem under conditions exactly paralleling those occurring under actual customer conditions. He, therefore, introduces conditions of higher temperature, higher pressure, higher speed, and so on, that will enable him to obtain results more quickly, and in doing so, he may completely distort the picture.

The study of fuel or lubricant variables in regard to exhaust valve life is a good example of this. The normal life of an exhaust valve is about 1000 hr, which would involve more than a month's continuous operation, day and night, or probably two or three years actual use. By running an engine continuously at high loads and high speed, conditions can be introduced that cause failure, say, within 100 hr, and this is obviously an attractive procedure for the impatient experimenter.

Unfortunately, however, the raising of valve temperatures gives rise to a range of deposits having melting points differing from those formed at lower temperatures, and these deposits have corrosive and other effects differing from those that are normally experienced. The experimenter may, therefore, be tempted to draw conclusions from such studies that are quite misleading when applied to the conditions operative in the average motor car engine.

Not only can he be misled by operating the engine at higher temperatures, but also by employing continuous instead of the intermittent conditions experienced in normal service. The cooling down of an engine and the heating up when it is re-started are essential factors in the life of any engine, and if such factors are not introduced into a test technique, misleading conclusions may be drawn.

All that I have said emphasizes the importance of continually reviewing critically the test methods used and being prepared to modify or adjust them as further knowledge may require.

Understanding the degree of accuracy in each test method used is basic in analyzing results of applied research

This knowledge may come from field trials. A stage may be reached in the development of a product in the laboratory at which it is opportune to try it out in the field to ascertain whether success is round the corner.

How frequently are these field trials disappointing! They are disappointing because of the non-recognition of some factor that may have been considered to be of secondary importance but which turns out to be the Achilles heel. Such failures, however, can be turned to good account. They can show in what ways laboratory techniques should be modified or extended, and if such disappointments are made use of, they can often become the turning point, not only in the development of a better product but also in the development of a better test method.

Before leaving the subject of test methods, reference should be made to the desirability of making full use of statistical techniques in developing new test procedures. In the early stages, correlation data are usually clouded by appreciable experimental errors, both in the test and field results, but in spite of this, statistical analysis of the data will, if the work has been properly planned, show whether the correlation is inadequate or might be made satisfactory if further work were carried out.

Statistical techniques should sometimes be used from the outset in the planning and preparation of an experimental program. In particular, given a knowledge of the magnitude of the experimental errors — which may be available from previous experiences — it is possible to predict the minimum amount of work that will be required to meet the objectives of the program. Quite apart from their value in achieving experimental economy, statistical techniques, by their insistence on detailed planning of the work, often have the salutary effect of crystallizing the objectives.

Special reference should also be made to the increasingly important part that analytical techniques are tending to play in applicational research, so much so that it is usually desirable to set aside a certain amount of effort for the development and application of newer techniques, especially physical methods of analysis. Such techniques are powerful aids in the study of deposits of various kinds (such as those occurring on the various parts of a spark plug) and in diagnosing troubles of various kinds.

Spectroscopy and spectrometry in their various forms have become essential for constitutional studies from which an understanding of the relation between composition and performance may emerge, thereby removing much of the trial and error approach in product development.

Organization

Studies of the performance of products in appliances may lead quite deeply into realms of research where engineer, chemist, and physicist have to collaborate. For example, in a research on cylinder bore wear, the engineer will study the influence of mechanical design and operating variables on wear, the physicist may bring the latest radioactive tracer techniques to facilitate wear measurement, while the chemist will use his knowledge to develop lubricants and additives to combat wear.

The problem is, of course, to make quite sure that all these kinds of research workers cooperate satisfactorily and take full advantage of the various techniques each can provide. This can best be done by a flexible organi-

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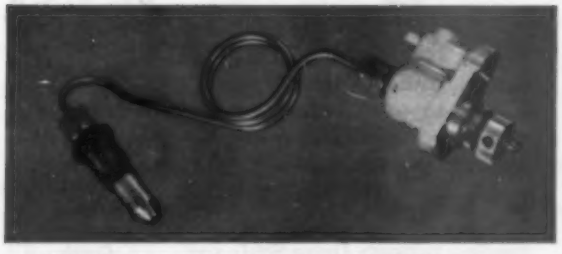

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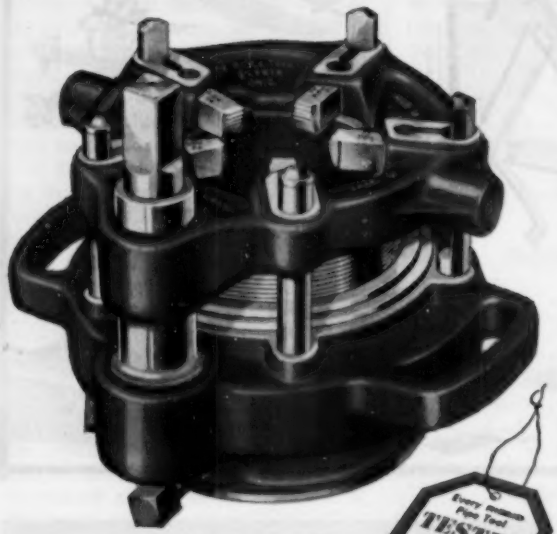

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zation that does not divide research teams into professions but into research objectives. If there is a particular problem on, say, the lubrication of gears, the engineer, chemist, and physicist should work side by side, each learning from the other and contributing his own special knowledge.

The general philosophy behind modern organization in research is that, broadly speaking, each employee is trained to be of most use in a particular sphere and that, by cooperation with others, more and better results can be achieved more cheaply than by indiscriminate individualism.

Services for Research

A large applicational research laboratory can be organized under the two main divisions of research and services. Research teams, each engaged on a particular project, must be supported by a variety of services, which include a machine shop and its associated drawing office; an instrument shop, where not only instruments can be inspected and repaired, but also developed; facilities for routine examination and analysis for chemical, physical and metallurgical properties.

In addition, there may be a photographic department, stores, printing and publications, library, and a section dealing with personnel problems and with the costs and budgeting of the laboratory. Roughly, for every man engaged directly on research, there is required at least another for the sort of sevices mentioned.

There is need for occasional compromise in this matter of centralization in service. While it may be necessary to have a centralized machine shop available for the research laboratory as a whole, it is sometimes justifiable to install a small lathe here or a small drilling machine there, adjacent to some rather highly specialized need. This may occasionally lead to increased efficiency and to greater interest and morale generally on some particular problem. Main purpose of a research laboratory, after all, is to produce original and good work, and not to run a highly efficient organization as an end in itself.

Free Exploration

A sufficient proportion of the entire effort of a laboratory should be devoted to a fairly free exploration of certain subjects, where both the man himself and the idea he has would appear to justify it. There are some classes of research for which it is impossible to predict the outcome, and, provided the facilities of a laboratory are not consumed in a number of wildgoose chases, it is desirable to encourage a certain proportion of effort that will not be subjected to rigorous scrutiny. There are, in every large research organization, a few research workers who should be given a large degree of freedom and who will do their best work under those conditions. There are others, however, who work best on the planned type of research with a fairly well defined objective.

In every case, successful results pre-suppose the right kind of scientist with adequate facilities at his disposal, with the best possible contacts with the field, and with plenty of help and advice from the marketing and manufacturing departments of his company.

I cannot refrain from quoting, in conclusion, the following: "The supporters of applied and developmental research are not content with the intellectual growth of the researcher. They want results—and they want them on time, before another company, industry or country attains them. This leads to research planning, to the definition of objectives, to directed effort, and to scheduling. Thus it is that the scientist in applied or developmental field is simultaneously lashed by necessity and stimulated by rewards. He is challenged by competition, disciplined by deadlines, judged by results—and he thrives and produces."[2] * * *

[2]OEEC Report on the Organization of Applied Research.

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A group that has achieved prestige for brilliant work for government agencies is getting sniped at by politicians hunting for election year issues

Ernestine Adams*

OPPONENTS of the National Petroleum Council are having a tough time. It seems as if the more investigations and the more incriminations thrown at the 10-year-old organization, the better it looks.

In case you don't know, the National Petroleum Council is composed of 102 top industry men from all branches who act as an information agency for Federal oil and gas agencies. The Council was a big help in the Korean emergency and its present service makes our nation more secure in peace time.

There is a small persistent faction in the Congress which apparently is attempting to whip up an anti-business-in-government political issue and NPC's stature puts it in the spotlight. That light has revealed, however, a constructive pattern of activity seldom equalled by any group. Both the Federal Government and the oil and gas industry can be proud of it. Resulting headlines have been good for NPC in that it has gained more attention from the industry and the public for its service.

In a negative way, if the chairman of the House Judiciary Committee, who has been trying to pin something on the Council for several years, has not found anything worse to report than his particular dislike for business influence in government, the NPC must be a paragon of government agencies. Of course, the New York Democrat isn't through yet, but he seems to be sweating more than the Council.

There's no getting around the fact that the National Petroleum Council is a bit out of the ordinary, but it is a natural outcome of World War II government organizations. At that time business and industry management provided members for production and distribution planning agencies. You'll remember there was plenty of time for the government to get ready for the tremendous job of producing enough to arm and fuel and feed ourselves and, to a large extent, our allies.

Peacetime Council Is Born

The Petroleum Administration for War was organized to administer oil and gas matters and the Petroleum Industry War Council was established to advise PAW in the mobilization effort. Together they did an unparalleled job of providing the power for victory. The arrangement of an industry advisory group came from an idea of the late Secretary of Interior Harold L. Ickes and its success won high praise from him and from the Military.

When the war was over and the PIWC's assignment completed. President Truman wanted some replacement for peace time. Then, as now, peace was pretty chilled and it looked as if any new aggression might be swift and fatal — no time for organization; only time for action.

The President assigned to Interior Secretary Krug the task of setting up a group to keep the government informed on the oil and gas industry. "I have been impressed", he wrote, "with the great contribution of government-industry cooperation to the success of the war petroleum program, and feel that the values of such close and harmonious relations between government and industry should be continued. I, therefore, suggest that you establish an industry organization to consult and advise with you."

Krug followed through and the National Petroleum Council was established June 18, 1946 with 85 members appointed by the Secretary of the Interior. They were chosen from every phase of the oil and gas industry including representatives of associations in various segments of the industry.

Tom Clark, who was Attorney General, stated that "The Department has no objection to the formation of industry committees to advise and consult with government agencies" under conditions of responsibility of the government department which appoints and uses the industry group.

No Secrets

From the first meeting June 21, 1946, at the Interior Department, there have been no secrets about the Council's work. Its reports are available to all. Few have bothered to watch its activities, however, except staff members of the Department of Interior and the Office of Oil and Gas, which command its services, representatives of the Defense Organization, State Department, Department of Justice, and other Federal agencies and sometimes a Congressman or so, often one to whom business and industry are suspect.

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*Management editor of *The Petroleum Engineer*.

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San Francisco, California

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Bradford, Pennsylvania

HARDEY, B. A.
Shreveport, Louisiana

HARPER, JOHN, President
Harper Oil Company, Inc.
Long Island City, New York

HARTMAN, I. W.
Hersee Building
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Ind. Petroleum Ass'n of America
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WRATHER, JOHN
1750 East Sunrise Blvd.
Fort Lauderdale, Florida

fidential are handled by the Military Petroleum Advisory Board, made up of about 20 industry experts.

NPC functions as a consultation service. It assembles factual data for the Secretary of the Interior or the Director of the Office of Oil and Gas when either makes a request for specific material. This request may come to the Interior Department from one of some 20 other agencies in the government concerned with petroleum but it must be cleared by the Interior Department and presented by them to the NPC Chairman, Walter S. Hallanan, president of Plymouth Oil Company.

Agenda Committee Has Veto

The request is turned over to the Agenda Committee, headed by A. Jacobsen, chairman of the board of Amerada Petroleum Corporation. If the Agenda Committee of the Council decides that the government request is not within its prescribed powers, the Council can refuse to undertake the task but this is unusual. The Agenda Committee was given this veto power so there would be no possibility of the Council infringing on antitrust laws. The organization is well aware that it must stay far away from any sign of antitrust infractions and each request is studied carefully from that legal angle. Under the careful guidance of the Agenda Committee, the Council confines its work to that of study, analysis, and fact-finding. It scrupulously refrains from engaging in planning or programming.

If approved, a committee is named to make a factual report on the subject of the government inquiry. Chairman Hallanan consults with the Appointment Committee under Frank M. Porter, American Petroleum Institute president, on selection of these committees.

Specialists Selected

After a committee is appointed from the Council, a working committee of the best available specialized authorities and scientists are chosen from industry to draft the technical report. More than a thousand experts in the industry, who are not members, have worked on NPC reports. What better way to get full and accurate information?

So far the Council has made 123 interim and final reports on a comprehensive range of subjects covering: Supplies of crude oil and products; facilities for refining, transporting, and storing crude and products; and organization of government and petroleum industry for any possible future national emergency.

These reports are the harvest of a new kind of government-industry cooperation. Some of the finest reports ever made about the industry have come from NPC. This is praise indeed when you consider the vast fund of information collected and reported on every year by a highly organized industry.

You might say the NPC is a culmination of years of petroleum industry organization — the industry learned early that broad progress abhors the dark paths of secrecy. Every company, every individual worker in the industry owes more to shared experience and knowledge than to any other single factor. The NPC has simply put to work for government purposes the great power of sharing information that it knows the industry is capable of.

Council Service Is Free

NPC work costs the government not one cent. No payment is made to the members or to the working committeemen who help make the reports. There are no traveling expense nor any other allowances.

The budget for headquarters and secretarial expenses, which runs around $100,000, is contributed by members or their firms. Amounts from each range from nothing to about $5000.

You can well imagine that this top-flight consultant service could not be paid for in money. Few of the members or the technicians and engineers could serve the government under a different type of organization. You can see from the list of members on the opposite page that would be virtually impossible to obtain such wide representation of the petroleum industry any other way than through this cooperation of industry and government.

Question of Chairman

There have been several attempts to change the Council chairmanship from an industry man to a full-time paid government official. This would, of course, change the whole atmosphere of the cooperative arrangement. The industry members would be working under a political appointee or civil service man. Selection of the person for the office could be influenced by political changes, which would reduce continuity and efficiency of operations.

As it is, Mr. Hallanan has been chairman of the Council since it was organized. He was recently re-elected by the members for the 10th year. Few persons know the personnel and the operations of the petroleum industry as well as this man.

R. G. Follis, chairman of the board, Standard Oil Company of California, and another experienced and respected industry leader, has been the Council's vice chairman since 1949. James V. Brown, who is at Washington headquarters, has been secretary-treasurer since 1947.

Things to Know About National Petroleum Council

1. *It was established by Democratic President Truman in 1946 to take the place of the Petroleum Industry War Council, which served during World War II.*
2. *It has been continued by the present Republican administration. It is non-partisan.*
3. *Its function is similar to that of a consultation service on governmental problems concerned with the oil and gas industry.*
4. *Its members (numbering about 100) are appointed by the Secretary of Interior from every segment of the petroleum industry. Every member has one vote.*
5. *Its reports are assembled only upon specific request of the U. S. Secretary of Interior or Director of the Office of Oil & Gas.*
6. *Its meetings are held four times a year in Washington, D. C. where headquarters are maintained.*
7. *Its budget is covered by contributions of members. There is no expense to the government.*

Under the present system the Council provides the government with complete and uncolored data in the reports, which must have the vote of the entire diverse Council membership.

Organization Report

One Council Committee report on Government Oil and Gas Organization stressed that "Experience has shown there should be a principal point of contact and cooperation between the Government and the petroleum industry."

The committee, headed by B. Brewster Jennings, chairman of the board, Socony Mobil Oil Company, emphasized some of the peculiar characteristics of petroleum which made a horizontal government organization difficult and suggested a vertical organization. For example, few other industries deal in liquids in volume and the petroleum industry has had to build up its own specialized means of transport, such as pipe lines, tankers, barges, and trucks.

The committee pointed out that most of the facilities of the industry, including oil and gas wells, pipe lines, barges, tankers, refineries and distribution equipment, are usable only in the petroleum industry and can therefore be co-ordinated on a vertical basis without serious conflicts with other industries.

Suppose the Council had a full-time government official as chairman. If he has the knowledge needed for the post he must be chosen from the petroleum industry. If he does not come from industry, he'd go to industry men for the information he must have about operations and personnel or he would be of little use to the cooperative purpose of the Council. Even small mistakes can hurt. Industry people will do their patriotic best when the objective is well reasoned, although it may be almost impossible; but there could be some rare snarls in operation without a seasoned and well regarded industry executive to oversee committee work.

So far the NPC has survived this proposal on the chairmanship without serious dissent. When the question came up in 1951, Attorney General J. Howard McGrath approved the position of Interior Secretary Chapman, that the Council should have a chairman of its own choosing. Secretary Chapman had contended that NPC was in a category by itself.

If the Department of Justice is worrying about the Council, it has little to disturb it. It is doubtful if any outside agency can watch the petroleum industry as well as its different segments watch each other. All factors are represented on the Council — East and West; producers, refiners, transporters, marketers; big companies and little companies; and 20 representatives of petroleum organizations that cover about everybody in the industry.

In addition, the reports never involve any agreements for joint action within the industry. Minutes are kept of each meeting and have always been available to government agencies and to Congress. We wish the Department of Justice had nothing harder to watch.

Rumor now has it that an "Executive Order" is in circulation which would require the NPC to take on a full time government official as chairman. This seems a step backward after the experience of the past.

NPC has shown its earnest non-partisan endeavor to offer full and patriotic cooperation to the government. Its predecessor, Petroleum Industry War Council, worked capably under the late "liberal" Secretary of Interior Ickes. NPC in turn has functioned efficiently under two Democratic Interior Secretaries, Julius A. Krug and Oscar L. Chapman. It continues to work well with the present Republican Secretary, Douglas McKay. ★ ★ ★

What They Say About NPC

I am very proud of this Council and the cooperation that exists between the petroleum industry and the Government. That is as it should be.

We just want to stay away from Government interference with business because this country was built by free enterprise, initiative and courage on the part of individuals, and not by the Federal Government telling them what they could do, except in emergencies.

Douglas McKay
Secretary of Interior

May 5, 1955

In my time, as Director of the Oil and Gas Division, I have become convinced that without the type of service rendered to the Government by this Council (NPC) the Government's preparedness planning with respect to petroleum and gas would be hopeless. It would be a random hodge-podge of amateur guesses and not a sound basis on which the Government could predicate its planning for potential war.

Hugh A. Stewart
Director, Office of Oil and Gas

October 20, 1955

The importance and need for this Council where every segment of the industry has an opportunity to express itself has been brought very forcefully to me. You must be alert to remain within the sphere of your authority and to discuss only matters which you are authorized to discuss.

Oscar L. Chapman
Secretary of Interior

December 9, 1952

The reports are of deep interest and of enormous value to the Government in the discharge of its responsibility.

Felix E. Wormser
Assistant Secretary of Interior

May 5, 1955

A group organized as this is (NPC)... renders a very great service to the government, as I believe you have, without any way infringing on any part of these restrictive statutes...

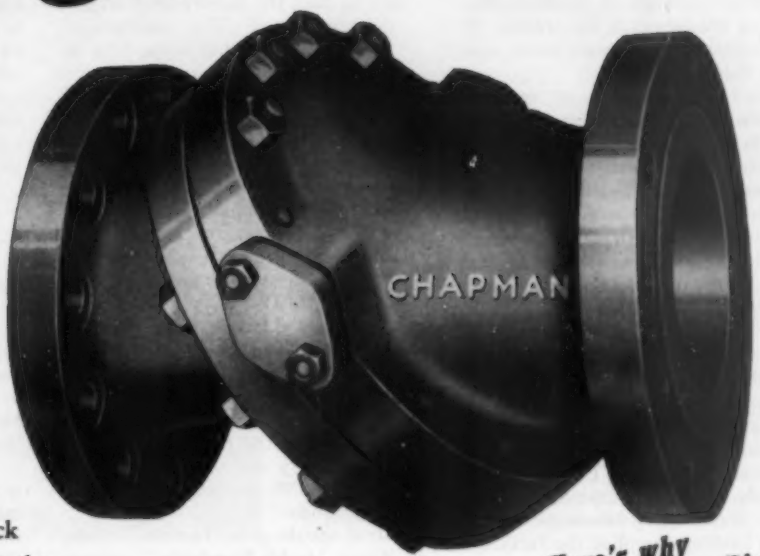
And so I am sure that so far as this Department is concerned, we shall continue to collaborate, to welcome your advice, to make up our own minds, and to make our own decisions taking into consideration the advice that we receive from you and a great many other things.

Clarence A. Davis
Under Secretary of Interior

October 20, 1955

Only Chapman Tilting Disc Check Valves give you

FAST TIGHT QUIET CLOSURE



Fast, quiet operation means low cost operation for check valves. That's exactly what the Chapman Tilting Disc Check Valve is designed to do. It won't flutter or slam and damage the piping joints or the valve itself. The unique drop-tight closure action eliminates scraping and wear of the disc and seat.

Rugged construction and low wear of the Chapman Tilting Disc Check Valves mean long life under severe operating conditions. Absence of vibration plus low head loss keep maintenance of the entire piping system at a minimum.

Whether for replacement or for new piping systems, be sure to specify Chapman Tilting Disc Check Valves. They're available in iron and steel for handling fluids or gases under a wide range of pressures. For full data on the complete line, write today. Ask for Catalog 30-A.

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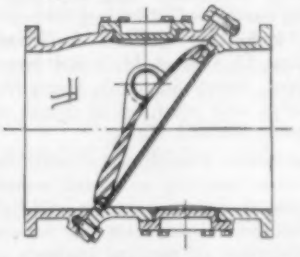
Here's why Chapman's Tilting Disc Check Valves Keep Quiet All of Their Lives



This specially designed "airfoil" disc balances perfectly in open position. The fluid holds the disc tightly against its stops without flutter. The body of the valve is larger around the disc, so the net valve area is at least as much as the pipe area to assure low flow resistance.

When the flow is reversed, pressure against the upper part of the disc cushions it as it closes. Then the disc drops easily and tightly to its beveled seat after the valve has swung closed. Seating is fast and quiet with minimum head loss in all but unusual piping arrangements.

"Medical service is not limited to handling of injuries . . . Its most exciting possibilities lay in preventing disease"

INDUSTRY AND HEALTH

A PATTERN for closer cooperation between industry and medicine was set forth at a three-day conference on "The Education of Physicians for Industry," at the Mellon Institute, Pittsburgh, Pennsylvania, in December, 1955. Participants called for:

1. More emphasis in medical education on requirements for practice in an industrial society—both inside and outside the plant.

2. Increased support of medical education and industrial health programs by corporations.

3. Stronger ties between industrial medicine and public health.

4. Recognition by both the medical profession and industry that the goal of medicine is the promotion of health, not simply the treatment of disease and infirmity.

The conference was sponsored by the National Fund for Medical Education, the Association of American Medical Colleges and two councils of the American Medical Association: the Council on Industrial Health and the Council on Medical Education and Hospitals. It was underwritten by the United States Steel Foundation. The Mellon Institute supplied the facilities.

Chairman of the conference was Dr. Robert A. Kehoe, director, Kettering Laboratory, College of Medicine, University of Cincinnati. Among the participants were 28 medical educators, 31 industrial physicians and five high-ranking executives of leading corporations, including: Clifford F. Hood, president, U. S. Steel; M. J. Rathbone, president, Jersey Standard; Harry W. Anderson, vice president in charge of personnel, General Motors.

The medical educators and industrial physicians, meeting in closed panels and general sessions, came up with formal recommendations not only for the indoctrination of medical students at the undergraduate and graduate level, but also on the training of practicing physicians to meet the needs of an industrialized society. They suggested:

1. That undergraduates be made aware of the range of medical interests that characterize industrial practice—that is the various aspects of (a) preventive services of a medical nature, (b) preventive services of an environmental nature, (c) curative services and (d) administrative and management counseling services.

2. That training programs for students (new M.D.'s preparing for industrial medicine as a specialty) be expanded where possible, with emphasis on field training and preparation to meet the requirements of the specialty board. The number of "certified" physicians in the field of occupational medicine today probably does not exceed 200.

3. That different programs be followed for the training of the three categories of doctors in industry: those with full-time practice, those with part-time and those who are simply called in by management from time to time. It was suggested that medical societies be encouraged to hold "M.D." days in industrial plants for the last category.

Occupational medicine was defined by one of the panels as "that branch of medicine which deals with the relationship of man to his occupation for the purpose of the prevention of disease and injury and the promotion of optimum health, productivity and social adjustment."

Hood, speaking on "Industry's Stake in Rising Health Standards," foresaw advance in industrial health not only in the protection of workers against toxic conditions, but in the fight against infectious diseases, diet improvement, mental health and glandular and emotional disturbances.

Rathbone speaking on "Our Debt to Medical Science," said that every segment of the population has benefitted from advances in medical science. "Industry came to realize many years ago," he said, "that an effective medical service was not limited to the handling of injuries, that its most exciting possibilities lay in steps that would prevent disease while maintaining and improving employee health—in other words, in the practice of preventive medicine."

Dr. Leo Wade, medical director, Esso Standard Oil Company, saw need for more progressive attitudes on the part both of medicine and industrial management. The industrial physician, he said, needs a "positive philosophy of life"—that is, as a health builder rather than as a healer—and management needs to accept the physician as a counsellor on the working environment and other conditions affecting the health of the worker.

"Health has to do with the adjustment of the total person—physical, mental, social and spiritual—to his total environment. It is in this area of fitting people to their working environment and fitting the working environment to people that the physician can make a tremendous contribution." ★

M. J. Rathbone, president, Jersey Standard; S. Sloan Colt, president, Bankers Trust Company, and president of the National Fund for Medical Education, and Clifford F. Hood, president, U. S. Steel Corporation.

Makes 37,500 ft. of hole

and Tiger Brand Line is still in excellent condition

"It was a lucky day we switched to Tiger Brand Rope," says Jack White, Tool Pusher. "We hit oil on all three wells drilled with this rope."

◀ Tri-State Drilling Co's Rig No. 2 going through a hard strata of limestone near Soso, Mississippi.

Jack R. White, Tool Pusher for the Tri-State Drilling Company near Soso, Mississippi, says, "We've drilled three wells with this Tiger Brand line and we struck oil in all three at a depth of about 12,500 feet. The line is still in *excellent* condition and good for a lot more work.

"We get such good service because we follow the recommendations carefully and 'cut in' the rope at regular intervals, so that the actual points of wear are constantly being moved. What's more, this rig has a new style grooved drum which goes a long way toward prolonging the life of any wire rope."

Tiger Brand Wire Lines come in many types to suit every drilling need. In addition to Rotary and Cable Tool Drilling Lines, there are Sand Lines, Torpedo Lines, Winch Lines, Hoisting Rope and Steel Guy Strand. Next time you buy line, get the kind that saves you money—Tiger Brand. Your nearby distributor has *just the line you need.*

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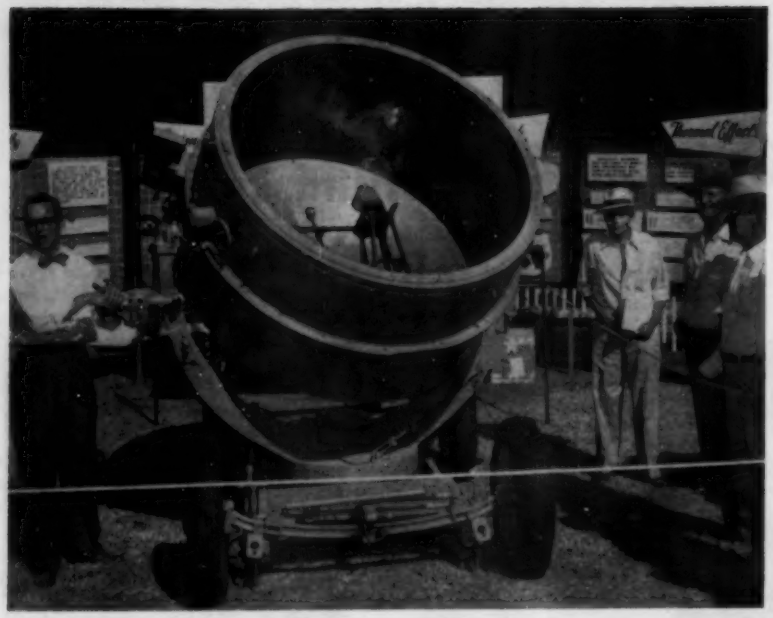

Convair solar furnace in action.

Industry Looks At SOLAR ENERGY

The energy of the sun is unlimited. Ever since the Stone Age, mankind has tinkered with ways to use it. But impatient Man found fire, electricity, fission and other things. The sun waits.

Today useful solar energy seems closer than ever—although big projects are far distant. In Phoenix last fortnight weary executives tidied their records after the biggest world conference on solar energy. The six-day meeting was officially called a "symposium" which some erudite delegates insisted was a "Greek drinking party" (its original meaning).

Whatever called, the meeting was a great success. When the idea was born two years ago the boosters hoped to lure 400 delegates. Final registration was about 1000 aside from 70 newspaper and magazine writers. Delegates arrived from 35 countries on six continents. The global representation ranged from Algeria to Lebanon to New Zealand. Said former U. S. ambassador and program chairman Lewis W. Douglas: "I am amazed—and impressed."

Arizona is a superb spot for a solar conference. The state gets more annual sunshine than any of the other 47; in some places the sun is rated 91% (sunshine days). Several years ago some Arizona boosters (perhaps irked by the hoop-la over atomic energy) decided to capitalize on their great natural phenomenon.

After months of plans they established the Association for Applied Solar Energy in March, 1954. Then they asked Stanford Research Institute to make a world-wide survey of possibilities. The pace quickened. Many hard months later they sponsored the recent World Symposium backed with the cash and efforts of such groups as the Ford Foundation, National Academy of Sciences, Rockefeller Foundation, U. S. Air Force, Office of Naval Research, UNESCO and National Science Foundation. Said one solar man: "This affair really starts us. Now all we have to do is keep it up."

Sun energy

Scientists like to talk about the sun with its tremendous mass (330,000 times the earth) and its unbelievable heat (up to 30,000,000 degrees). Ancient men worshipped their Sun God; modern man would like to put the sun to work. If ever effectively harnessed, the results could be astounding since on a summer day the sun can deliver the equivalent of 5000 hp an acre.

Not long ago two researchers named Ayres and Scarlott put it another way: it would take the sun only three days to outlast the complete combustion of all known earth fuels. And while earth fuels (coal, uranium or otherwise) are limited it takes the sun one billion years to lose an estimated 1%. As one solar scientist expressed it: "When the sun is gone, it won't make any difference."

Historical notes on solar energy go back many years. About 250 B.C. Greek inventor Archimedes repulsed an enemy fleet with fire rays from solar reflectors; many centuries later the sun powered a printing press at a Paris exposition; still later a Frenchman named Monchot perfected and patented a solar boiler.

Some of the early U. S. experiments were right in Arizona. While a few idlers jeered, a cone-shaped 700 sq ft collector generated 156 lb of steam pressure in Willcox in 1903-04; about the same time solar "extraction" experiments took place in Hardyville. In most cases the adventurers ran out of cash and enthusiasm before they developed anything of economic value.

Sun potential

Because they have so much sun and so little water, Arizona and several other Western states could use solar energy. One of the features of a "Sun at Work" exhibit at the symposium was a solar irrigation pump which noiselessly lifted water all day.

With scientific enthusiasm some sunstruck boosters carry the irrigation idea several hundred miles further. They envision a solar converter to make fresh water out of sea water (it can be done). Then solar energy would splash fresh water on the sun-dried desert and turn it into gardens. One big hurdle: money. In the symposium's headquarters in the colorful Westward Ho Hotel, one delegate remarked: "If we only had a tiny fraction of all those billions spent on atomic energy."

Despite the shortage of money, many things have been accomplished. The sun has supplied hot water to some U. S. householders for many decades (example: Florida). There have been attempts at a complete solar heated house but man has lagged behind the sun. One experimental home 40 miles outside of Tucson gets all necessary conditioning but it costs twice ordinary systems. There are a batch of solar cookers and boilers, many of which are

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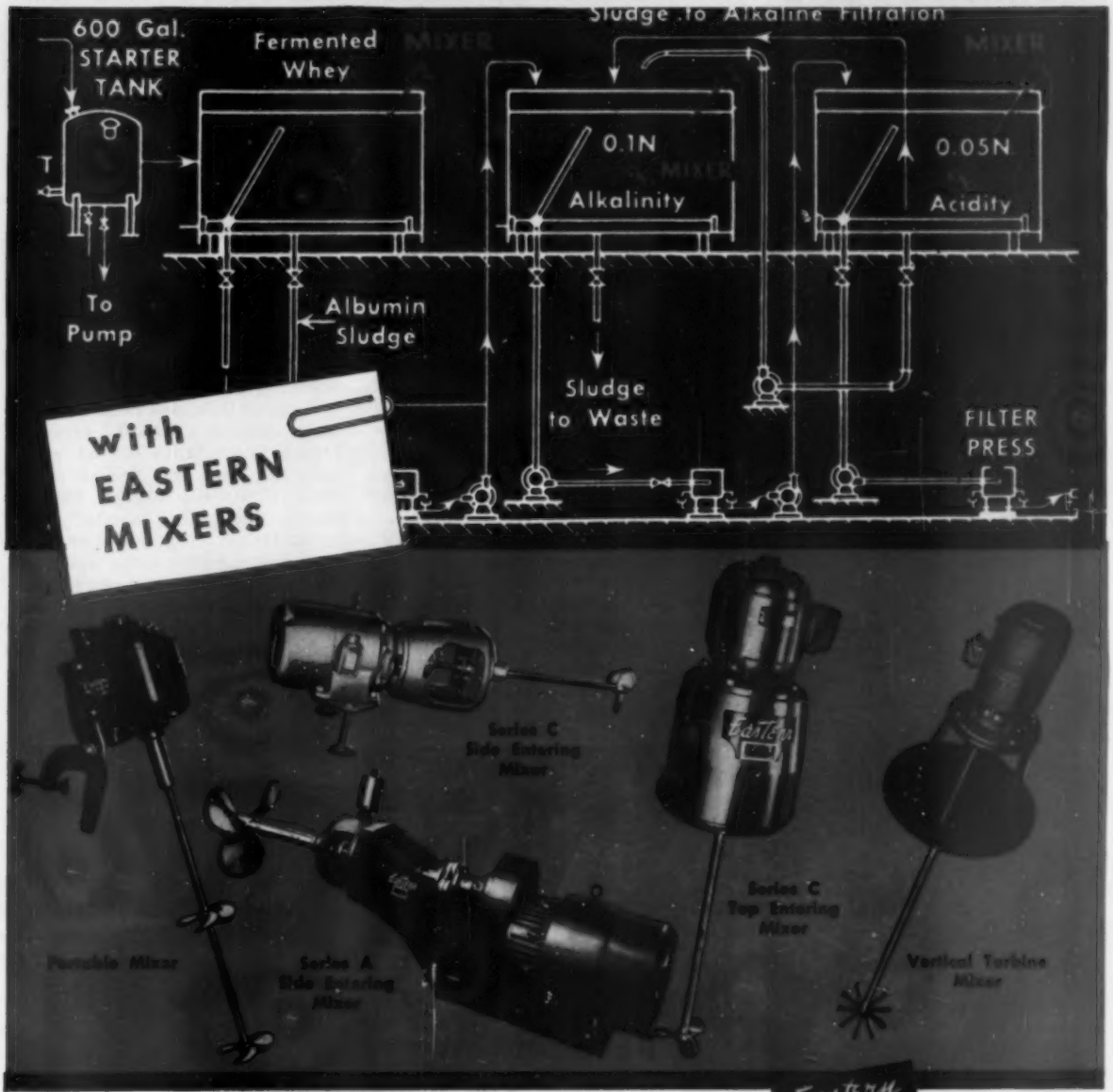
RELIABLE FLUID MIXING in PROCESSING



Eastern's Mixers are designed to meet the needs of today's chemical and industrial processes. Many types are available to satisfy all conditions of fluid consistencies and tank sizes. Selection may be made from a wide range of horsepower, speed, and construction materials. Motors with various voltage ratings and enclosures are also furnished.

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Series H at 1725 R.P.M., Series S at 1125 R.P.M., and Series G at 420 R.P.M. are available in motor ratings from 1/20 to 5 H.P. Also available are special speeds, variable speeds, as well as air driven models.

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Series A, extra heavy duty for large tanks, are available in side entering units only within a range of 5-30 H.P. with standard speeds of 280, 420, and 1150 R.P.M.

Series C, for average tank capacities, are available in sizes of ¼ to 10 H.P. at these standard speeds: 1725 R.P.M. (up to 5 H.P.); 1140 R.P.M. (up to 10 H.P.); 420 R.P.M. (up to 7½ H.P.); 280 R.P.M. (up to 5 H.P.). Available in both horizontal and vertical models.

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Eastern's Top and Bottom Entering Turbine Mixers find particular application where liquid blending requires gentle, yet thorough agitation.

Models are available in sizes from ¼ to 40 H.P. Standard speeds are 56, 68, 84, 100, 125, 155 R.P.M.

For 3 bulletins covering Eastern Mixers, request Catalog Series 25.

Eastern INDUSTRIES, INC.
Mixer Division
Regent St., Norwalk, Conn.

practical wherever sun is plentiful and other fuel scarce. In both India and Burma solar cookers are produced and sold for $25 down to a dollar or two.

Both U. S. and Japanese scientists have experimented with forced-growth plant life via solar energy. Some types of algae develop very rapidly in sunlight and produce protein which is comparable to milk or eggs. This would make excellent animal feed and someday might feed humans.

Perhaps the best example of modern application is American Telephone's solar battery which turns the sun's rays directly into electrical current. This tray-like arrangement is perched atop telephone poles in rural areas where it supplies just enough booster current to carry the voice. Company executives are happy about the battery but admit it is only 11% efficient.

Sun future

Solar energy fans radiate when they talk about the future. Their two main points: (1) the fuel is cheap and unlimited; (2) because a solar collector has few moving parts, repairs and maintenance would be little. However, this skips over the initial investment which could be huge.

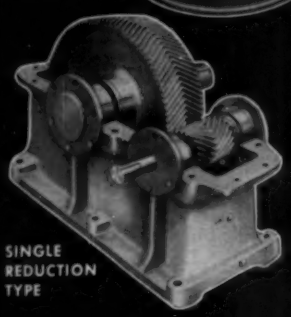
The Arizona Public Service Company hopes to be the first utility to build a large solar power plant. Giant reflectors on the desert could generate steam to turn the turbines; the juice would be wired into homes and factories.

Another sun-power idea is individual solar collectors on every housetop; the fuel would be free but the utility company would serve as installation, backstop and maintenance crew. But nobody is sure what this would cost nor how soon present theories and experiments can be turned into reality.

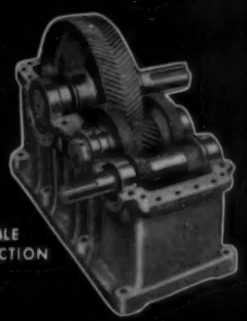
Dozens of other companies try to get the sun on their side. Johns-Manville is interested in the household applications, Pillsbury Mills eyes the possibilities in food and mighty duPont works diligently and says little. Still other companies watch, wait and say nothing at all (General Motors, Borg Warner, Detroit Edison, etc.).

Many of these will certainly watch the progress of a big solar project in French West Africa—of all places. Near the village of Abidjan on the Ivory Coast the French Thermal Energy Society has invested almost $3,000,000 on an unusual plant to generate electricity and pump water, too. The basic idea is to utilize the temperature difference between the cool deep-sea water and the sun-warmed surface water. The idea was tried before and failed. This time the Frenchmen are sure it will work. * * *

HERRINGBONE REDUCERS ... by PHILLIE GEAR



SINGLE REDUCTION TYPE



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Model "1000"

THE ELECTRIC AUTO-LITE COMPANY
INSTRUMENT AND GAUGE DIVISION
TOLEDO 1, OHIO
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TEMPERATURE RECORDERS

Fig. 1138 (left) non-rising stem, Fig. 1140 (right) OS&Y... two of 29 OIC iron valves with steel valve features. Metals used for trim and pressure parts in this line include: bronze, manganese bronze, nickel-plated steel, higher strength iron, nickel-alloyed iron, Monel, 18-8 stainless, 11-½-13 chrome.

Reduce valve wear. Choose from 29 OIC iron valve numbers with 9 different trim and body metal variations. Depend on them for general use and process industry services handling alkaline liquors, creosote, sour crude, sulphuric acid and caustics.

Working parts design assures positive seating . . . long life

Seat rings are end seated, reducing the probability of loosening in service and affording streamlined flow from port to port. Body wedge guides and a flexible T-head stem-wedge connection combine to assure accurate wedge seating for tight shutoff.

Extra strength adds safety to pressure parts

High-strength iron castings assure pressure parts made to a minimum tensile strength of 31,000 psi. The body and bonnet, elliptical in shape, resist internal pressure with least possible distortion. Body-bonnet bolting provides uniform gasket loading and, consequently, a pressure-tight seal throughout the pressure range of the valves. Tie ribs, cast between the pipeline flange and the body bonnet flange, prevent distortion from excessive pipeline stresses.

This line's many added features, trim variations, dimensions and end openings are completely described in the new OIC specification folder, Form No. 1005. Write for it.

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Waste Gas to Be Recovered by

New Pine Island Plant

Gasoline extraction plant – low pressure gathering system, will convert for sales 20 million cubic feet of gas now being vented. Ultimate development to process 40 million

THE largest oil and gas field in area extent and the second largest producer of oil in the state of Louisiana is the Pipe Island field of Caddo Parish. It is a "stripper" field of approximately 4000 wells pumping less than 10 bbl of oil per well each day from an average depth of 1300 ft.

Only a small volume of natural gas is produced with the oil, about 12,000 cu ft per well, but in the agregate this represents 48 million cubic feet of gas daily. Two gasoline extraction plants are processing a total of 5 million cubic feet of gas daily but after the gasoline is extracted and a small refinery supplied with fuel, 4 million cubic feet of gas is blown to the air as residue by these plants.

So, out of about 48 million cubic feet of gas produced in the field, when allowance is made for lease fuel, at least 40 million cubic feet of gas with a natural gasoline content of two gallons per thousand cubic feet is wasted to the air each day.

This wastage of gas has been going on for a long time as the field was discovered in 1905 with its all time peak of production in 1918. The low formation productive capacity of the wells, even with productive sections in excess of 100 ft, has resulted in a spacing pattern of one well to each 5 acres. Nevertheless, the remaining reserve of oil and gas is tremendous.

For instance, the 2200 wells under standard "Casinghead Gas Contract" to Gulf Natural (now producing 27 million cubic feet of gas daily) according to reputable geologists and petroleum engineers, have an estimated total gas reserve of 167 billion cubic feet of gas. This could supply Gulf Natural's initial need for more than 20 years.

Of particular interest is the extensive ($750,000) gathering system which will collect the casinghead gas production from some 1700 of these wells producing from the Annona chalk formation. On a field average, each well produces approximately 12,000 cu ft of gas per day, as previously stated, resulting in an initial gathering capacity of 20 million cubic feet per day.

When completed the natural gasoline extraction plant will process a minimum of 20 million cubic feet of gas per day. The dry gas will be sold to the Arkansas Louisiana Gas Company at an average price of 12.97 cents per 1000 cu ft.

Additional gas production is available to the plant, and it is anticipated that the gathering system will be expanded as soon as the initial operations have been stabilized. The initial gathering system will consist of approximately 65 miles of lines, the main trunk lines being 24 in. and 26 in. in size.

The plant compression facilities will be of conventional design with a total of 4400 compressor horsepower. Compressor foundations and piping are designed to facilitate rapid expansion.

The liquid recovery facilities will be a refrigeration type plant employing glycol injection. The chiller will operate at 0 F at 500 psig. Condensed

Day's plans being checked at field office. Plant and system will initially produce a specification natural gasoline.

liquids from the low temperature separator will be charged to a stabilizer, using a cold feed reflux system.

Initially the plant will produce a specification natural gasoline product only; however, the stabilizer has sufficient trays, so that it may be converted to a deethanizer when the economics warrant the production of an LPG product. The refrigeration system will employ propane as a refrigerant, with 440 refrigeration compressor horsepower.

In order to reduce the electric load of the plant to a minimum, virtually all pumps and the cooling tower fan drives are steam turbines. The steam system will be a closed system with 90 per cent return condensate.

The closed steam system is especially warranted in this plant, because of the hardness of raw water available to the plant. A test well drilled indicated that the only water available to the plant was a shallow high volume sand, having water with a total hardness of 540 ppm. Raw water make-up to the boilers and cooling tower will be treated externally with a cold lime-soda system.

Construction is running 30 days ahead of schedule but the starting date was postponed 120 days due to right-of-way difficulties. As in many of the older fields, the oil companies purchased the land in fee and later sold the surface rights to farmers, oil field workers, and others. Not receiving any benefits from the gas to be sold to Gulf Natural, these land owners presented a problem, but it has been reconciled.

Over 100 separate gas purchase agreements were made to cover the 2200 wells and approximately 500 leases. While a few operators such as The Texas Company, Sklar Oil Company, Arkansas Fuel Oil Company, Alvin Johnson, Kolar Lebow, and J. C. Trahan operate from 100 to 300 wells each, there are many 1 to 10 well operators in the field. Just locating the latter group was a herculean task, but that is all history now.

Before it was decided to expend $2,000,000 on this project, a small highly specialized group of experts were retained to study and plan. Then, this same small team have done the job in record time. Alphabetically, they are:

Don Attaway, works manager, with 26 years gasoline plant experience; Hazen W. Cole, Shreveport attorney supervised the buying of rights-of-way; E. A. Courtney, consulting geologist of Hammond and New Orleans; Alec Crowell, Natural Gas Consultant of Shreveport handled gas supply and sale; J. B. Harris, process engineer of Dallas designed both gathering system and plant; Margaret E. Lauer, New Orleans C. P. A., served as coordinator for the entire undertaking; and James (Tiny) Simmons has been responsible for all material and construction. Prime contractor is Snelling Brothers Corporation of Shreveport. ★ ★ ★

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In brief, these Paracril "O" rings are *leakproof* and *lasting!*

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If you're not already familiar with the *many* advantages Paracril offers *you,* simply write on your letterhead to the address below.

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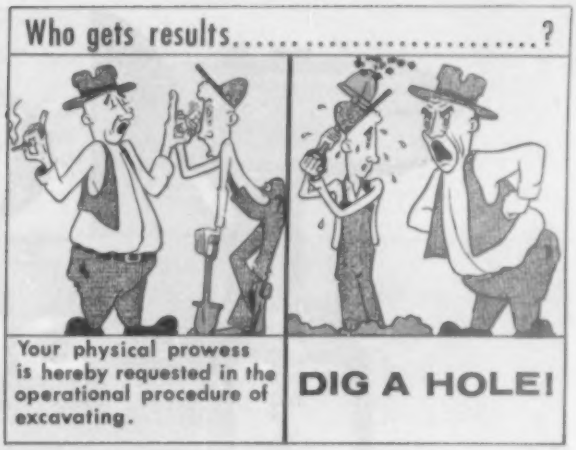

Dennis Murphy*

Communication:

words resemble people— they're our employees!

COMMUNICATION is a matter of word-management. Since words are our workers in this eternal process, we ought to learn all we can about them—their kinds, duties, effects, and how they are managed. We have to make sure that we employ the right words and that they do precisely what we want done. What study, then, could be more useful toward business management or executive development?

Many a supervisor may know his work thoroughly but mismanage his communication by allowing words to loaf on the job, tyrannize over him, detract from his performance, and demoralize his thinking. Words are our living helpers, not dead entities, and each word has its individual traits and capacities. But we should learn to make each one do our exact bidding. Communication is a skill that requires precision, patience, and practice.

Since words are as different and changeable as people, whom they resemble in many respects, this article will try to suggest ways of managing words better as a means to managing employees better.

The Nature of Words

1. **Words are symbols to evoke something else.** Through print, script, or sound they refer to some concept, image, idea, or thing. The problem is to get a word to evoke the same thing in two minds at once. Because this is really impossible, we settle for a workable meaning. When two people agree on a common referent or meaning behind the word-symbol, communication can begin.

2. **Words have many meanings.** Since one word may have many referents, both the sender and the receiver must connect mentally on the intended meaning, the right meaning. "No, I don't mean that!" is a signal that either the sender or the receiver is off the track. If understanding is difficult between two persons, the difficulty increases with more persons involved. The miracle is that we have as good communication as we have!

3. **Facts are statements that can be verified.** Several examples are H_2O, 60 mph, 4:47 p.m., and "the square of the hypotenuse of a right triangle is equal to the sum of the squares of the two legs." Men and women, Russians and Americans, Jews and Gentiles, old and young—all accept scientific facts. Objective facts may result in writing as dull as a telephone directory, but people don't argue over them.

4. **Inferences are statements about the unknown.** They're made on the basis of the known, but error lurks here. We may draw a wrong or unwarranted inference from the data we have. In the chain of reasoning we may miss a link and conclude wrongly; or in testing the evidence we may misjudge. And so, while we feel comfortably just in making *our* inference, we may discover that the other fellow has arrived at an inference far different from ours.

5. **Opinions are judgments we form about persons, places, or things.** Usually they are sentiments arrived at from experience. Milton said that "opinion in good men is truth in the making," and we tend to accept the authority of men of position and leadership. But there's plenty of room for error here because all men make mistakes. As Voltaire said, "I don't believe a thing you say, but I'll defend to the death your right to say it." So, in all communication we must allow for difference of opinion and try to disagree graciously.

What's in a Word?

As to grammar, each word is called "a part of speech" that is always determined by what it does in a particular sentence. Thus *fast* may serve as a noun, a verb, an adjective, or an adverb—depending upon its use. This changeable function of words corresponds to the changeable title and function of workers in different firms.

As to nature, words resemble people by being primarily active or static. Verbs and nouns are active, even volatile; adjectives and adverbs are far less so. We can best infuse new

*Administrative Assistant, Service Pipe Line Company.

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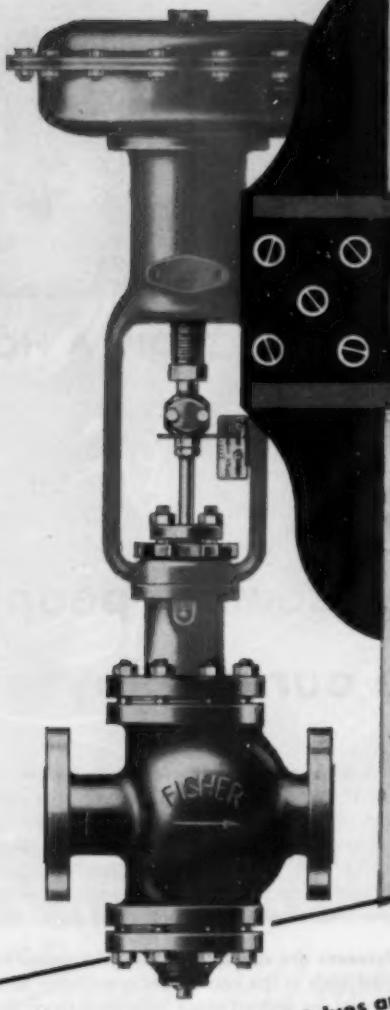
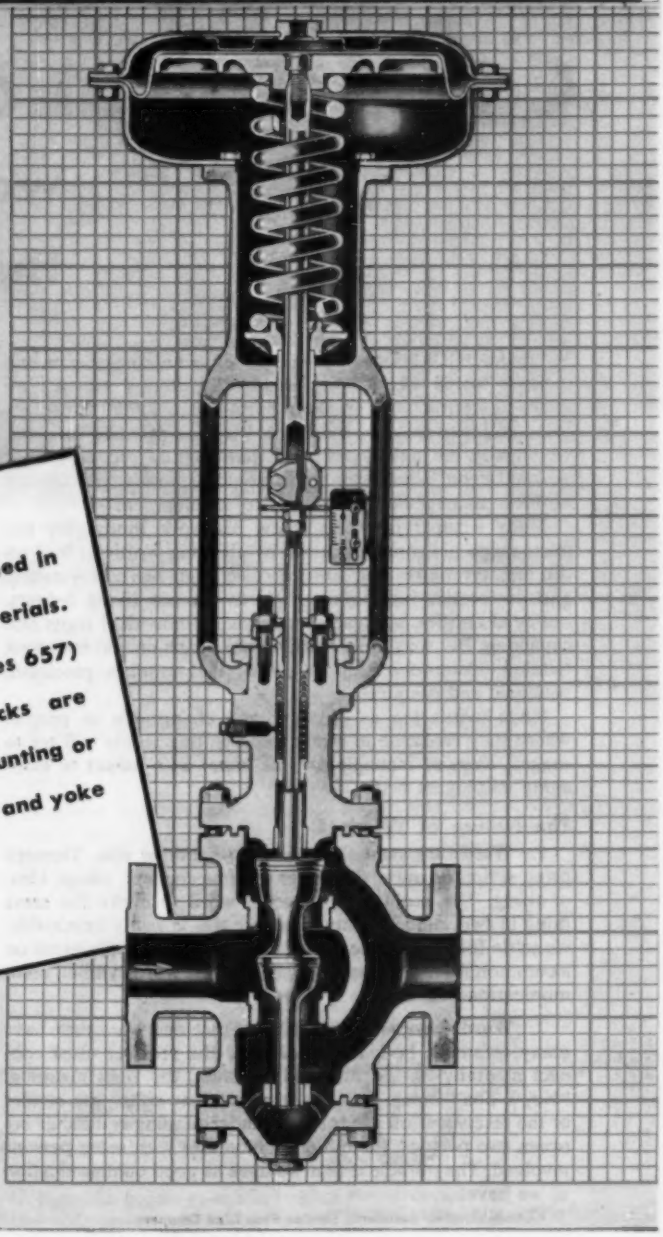
DIAPHRAGM





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life into a sentence by giving the verb a blood transfusion. Verbs are the veins and arteries of the sentence. *Verb* comes from Latin *verbum*, meaning "word," and the Chinese call all verbs "live words." The verb is indispensable in the sentence; compare "Go!" with its more colorful brother, "Scr-r-am!" *Noun* comes from the Latin *nomen*, meaning "name." Specific verbs and nouns strengthen our sentence.

Many businessmen hope to improve their writing by using more adjectives and adverbs. This is a mistake; the opposite is usually true. In fact, an adjective often fights with its noun, as when the old pipeliner said, "I'm against any goddam profanity around here!" Thus "the heroine whispered" says as much as "the beautiful brave young girl spoke in a very low soft voice" and says it four times as economically. Words like *very* and *interesting* do little except clutter up the sentence. We should use adjectives and adverbs less often but with more care.

Key Words and Helpers

As to function, words may be classed as content workers and structure workers. In many ways they resemble line men and staff men.

1. **Content words**—main verbs, nouns, adjectives, and adverbs—are the "key workers" who carry the meaning and do the most important job. Roughly, of the 600,000 words in our language, about 80 per cent are content workers.

2. **Structure words** are the articles, auxiliary verbs, pronouns, prepositions, conjunctions, and some adverbs. They are usually short, simple, and familiar "helpers" that support and hold the content together, but they carry little meaning in themselves alone. All auxiliary verbs like *is, was, were* (all forms of *to be*), *shall, will, should, would, have, has,* and *had* are connecting tissue in our sentences.

Although structure words comprise only 20 per cent of our total words, 25 per cent of all adult writing consists of these ten structure words: I, you, we, a, the, and, for, to, of, in. To simplify writing, then, we need to watch the long content words—nouns, verbs, adjectives, and adverbs with many syllables.

What Do You Mean?

As to use, content words have two sets of meanings. One is the logical **denotation** found in a good dictionary; the other is the emotional **connotation** suggested by experience. The first gives the character; the second, the reputation of a word. The noun *cross* denotes two transverse wooden beams, but by association it connotes far more to most people. A seventeenth-century Englishman named Derrick devised a heavy scaffold for hanging criminals; to oilmen today *derrick* connotes something different.

Justice Holmes (245 US 418, 425) wisely wrote: "A word is not a crystal, transparent and unchanged; it is the skin of a living thought and may vary greatly in color and content according to circumstances and the time in which it is used."

Some employees, like the early Roman soldiers, are not worth their *salary* (salt money), and some employers do not live up to the denotation of their *company* (break bread with you). Most businessmen will be rewarded if they look up the history of words like *banker, broker, money, calculate, comptroller, amortize, panic, secretary, supervisor,* or *A-1*. Words, like people, are alive and fascinating because of their heredity, environment, and intrinsic worth.

If we could all agree to use only accepted definitions, communication would be much less liable to error and misunderstanding than it is. But no word ever has exactly the same meaning twice, and no word ever means exactly the same thing to any two people at a given time. Therefore, accurate communication is difficult because personal judgments, inferences, opinions, and prejudices keep creeping in. Words often say less than they suggest. For example, contrast "the crackpot politician sneaked in" with "the congressman with unusual views entered quietly." Both treat the same fact—but how differently!

Learning To Manage Our Words

Everything said so far is intended to encourage us to control words that do our daily work. Who shall be the master: we or our words? Nothing in life, unless it be our actions, reveals us more clearly than our language—that integral part of us that comes right out of our innate thinking, personality, and character. That's why word-management is so important to all of us and especially to businessmen.

We need to learn how to assign words in the best working order, to curb refractory ones that go beyond our authority, to quell those that monopolize every expression, and to cultivate others that deserve more employment. Maybe we need to evaluate some oldtimers we've put up with too long, and employ some vigorous new workers to improve our communication jobs.

Let's look at a few word-workers that are "problems."

Trite Words

Trite words are those so overworked that they no longer have any life, freshness, zip. The French call them *clichés*, meaning "stereotyped." Structure words—*a, an, the,* conjunctions, and prepositions—never grow hackneyed but content words do. Even bright and sparkling figures, through overuse, become washed-out and insipid.

A skillful manager of words tactfully avoids these drones because they never turn in a full eight-hour-day's work. Worn-out and commonplace, they're more excusable in daily conversation than in writing. But they put any manager in a hole by making him appear to be a rubber stamp given to tabloid thinking. Here are a few of them to avoid:

Pumping Progress Report

FOR HYDRAULIC ENGINEERS

An advertisement prepared by the Aldrich Pump Co., Member of Hydraulic Institute, U.S.A.

PUMP INSPECTION, MAINTENANCE AND REPAIR are jobs too frequently ignored in the design of production pumps. This has been verified by a survey of more than 15,000 pump installations. Speed and economy of maintenance was frequently quoted as a major factor in pump selection.

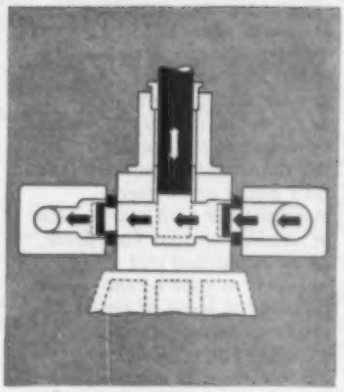
SECTIONALIZED FLUID-ENDS offer one of the best ways to guarantee both speed and economy in pump maintenance. As originated by ALDRICH Pump Co. Engineers, the Sectionalized Fluid-End comprises four main assemblies — the working barrel, suction manifold, discharge manifold and stuffing box.

SPEED IN MAINTENANCE is assured because of ease of accessibility of all wearing parts. Manifolds can be slid back on studs and valves removed as complete units. Split collar and flange connection of plunger to yoke permits easy removal of plunger.

ECONOMY OF MAINTENANCE results from speed in maintenance. Perhaps even more important is the simple fact that it is cheaper to replace a single section than a complete fluid-end. Another important economy is parts interchangeability. Among 3-, 5-, 7- and 9-plunger units of any series, wearing parts are interchangeable. Where a combination of multiplex pumps is required, this reduces spare parts stocks.

THE ALDRICH PUMP COMPANY is the originator of the DIRECT FLOW principle — a design innovation that utilizes the sectionalized fluid-end principle. Aldrich Engineers have become known as the people to take your tough pumping problems to. We have never turned down a challenge.

FURTHER INFORMATION can be had direct from the company. Tell us your problem and we'll send you Data Sheets describing the size pump we recommend to solve your problem. Address your request to: The Aldrich Pump Company, 26 Pine Street, Allentown, Pa.



Aldrich Direct Flow Fluid-End Design

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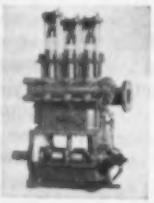
The Direct Flow principle, an Aldrich design innovation, is a major forward step toward the solution of tough pumping problems of all kinds. Not only does it eliminate two right-angle turns in the fluid-end, but in addition makes possible complete Fluid-End Sectionalization. This is another Aldrich design innovation which permits economies of maintenance and repair offered by no other type pump.

CHECK THESE ADVANTAGES OF SECTIONALIZED FLUID-ENDS:

Less expensive parts replacement
Ease of inspection and maintenance
Interchangeable wearing parts
No special equipment for valve removal
Easily accessible stuffing boxes



Write today for Data Sheets describing the Direct Flow Pump Series.

THE ALDRICH PUMP COMPANY

Originators of the Direct Flow Pump
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Representatives in principal cities

after giving due consideration
as soon as possible
assuring you of our cooperation
at this time we wish to state
at your earliest convenience
beg to advise and beg to remain
contents carefully noted
for your careful consideration
fully aware of the facts
in accordance with your request
in response to your kind favor
please be advised that
pursuant to your recent request
referring to yours of recent date
resort to drastic measures
thanking you in advance
too numerous to mention
your kind and esteemed favor

Pompous Words

Businessmen and others use big words because of habit, the desire to show off, or a misguided attempt to "improve" plain expressions. Some word-managers mistake pomposity for dignity, but Fowler in MODERN ENGLISH USAGE says "the better the writer, the shorter his words."

Sometimes a big word is the right one—if the subject calls for it, the receiver understands it, and the employer uses it correctly. Where everyone knows what *decentralization* means, for instance, we don't economize by writing *break up into smaller units*. But when big words for little ideas keep piling up, look out! We lose our reader. *Peruse* for *read*, *domicile* for *home*, *utilization* for *use* soon make him sick. Why make him beat his brains out on "subsequent regulations governing transportational procedures" when we can say "later rules for shipping"? Short words that are not highfalutin can say exactly what we mean and make our writing easy to read and understand.

The trouble with pompous words is that they make stuffed shirts out of us. They betray us. They alienate us from other human beings. They disgust our readers or listeners, causing them to doubt our sincerity, honesty, integrity—our character. Pomposity has cast a stigma on business writing that's going to take a lot of effort to erase.

Although the number is endless, here are a few pompous workers that have been deflated:

aggregation	— total
approximately	— about
assistance	— aid, help
commendation	— praise
commercialization	— commercial
customary channels	— usual way
effected, effectuated	— made, did
endeavoring, attempting	— trying
equivalent	— equal
functionalization	— use
instantaneously	— now, quickly
instrumentalities	— means, ways
involving, concerning	— about
procedural practices	— what to do and how to do it

Someone may aptly ask "Why increase our vocabulary if we shouldn't use any big words?" Often we need some unusual word and use it with propriety, but if we lug it in awkwardly it seems to shout "Look, I'm a big word you don't know!" We should enlarge our vocabulary to help us in reading and understanding, but our audience will determine how many big words are in good taste. Unfamiliar words work like a drug: harmless in small doses but deadly in excess. Flaunting our word-supply is like parading our wealth—and with much the same effect. It's more likely to depress than impress.

Superfluous Words

No manager would think of hiring twelve employees to turn out a job that four could do. Yet businessmen everywhere go on employing three or four times as many words as needed to do their communication job. Misers with money may be wastrels with words—an odd paradox because words are not cheap but expensive, sometimes costly. Unnecessary words are great loafers that clutter up work, usurp the most important position in a sentence, and create confusion.

it was the manager's contention	— *the manager contended*
there were no reports issued *by* the company	— *the company issued no reports*
there have been times when	— *sometimes*
there are many employees who go	— *many employees go*
is was then that we first learned	— *we first learned*
it is the belief *of* the president	— *the president believes*
there are some products *that* have	— *some products have*
there is a possibility *that* some *of the* employees	— *possibly some employees*

Superfluous words often gang up in pairs to appear strong and emphatic but play havoc with work simplification. Notice these doubles:

each and every man, woman, and child	— *everyone*
he, she, or it, as the case may be	— *he*
accordingly and consequently	— *therefore; so*
rules and regulations	— *rules*
first and foremost	— *first of all*
deeds and actions	— *acts*
fair, just, and equitable	— *just*
leases and lets unto	— *leases to*

Abstract Words

Vague blanket words are wishy-washy and indefinite. In pretending to cover everything, they cover nothing. They result from muddled thinking and the lazy habit of letting any old word do. They reveal a word-manager who's still "up in the air" and unable to get a close hold on his material.

Compare "Operations have been extended into this northern producing area by one of the petroleum transportation companies" with "Service Pipe Line Company laid 23 miles of gathering line near Tioga in the Williston Basin of North Dakota." Or compare "One of the company's representatives explained the nature and characteristics of the proposed facility and commented with respect to its installation" with "Mr. Willis, chief engineer of Fairbanks-Morse, described the dual-fuel engine and told how to install it."

We can't avoid all abstract words, nor should we. Words like *greed*, *fear*, *war*, *love*, and *success* are inevitable but should be made specific by details. One trouble with abstract words is that they're *not pictureful;* so they're hard for the reader to grasp because they don't give him enough concepts to prevent fatigue. Another trouble with them is that they're *not exact.*

Lack of exactness makes these words the most dangerous to use because they permit so much misinterpretation and misunderstanding. A general word like *tree* will mean twenty things to twenty people, whereas a specific word like *silver birch* will exclude a lot of trouble arising from different meanings. Mark Twain once said "the difference between the right word and the almost right word is the difference between lightning and the lightning bug."

Here's a list of abstract words that seldom get close to any idea:

concerns	capacities	conditions
affairs	properties	functions
activities	procedures	operations
relations	economics	changes
facilities	effects	systems

In fairness, we must admit that business writing may purposely be vague, general, or abstract. It's a trick of the trade. Why should one firm reveal specific details about its business when other firms don't reciprocate? Competition could be killed by such a practice. Revealing only what is proper, being noncommittal or evasive, and using general terms may result in poor writing—but mighty good business. Being secretive is necessary at times, but this recognized fact doesn't excuse most abstract writing.

Foreign Words

Technical writing calls for the precision of technical words, most of which are foreign. But a top-notch lawyer, doctor, engineer, professor, or any other learned man makes an affected ass of himself when he tries to advertise his learning through monstrous words. His audience should determine his usage; he may spout technical terms for others in his profession, but he should use a layman's language for the public.

A parade of foreign phrases will sabotage communication because our English language is quite adequate. Fowler says that "short words are not only handier to use, but more powerful in effect; extra syllables reduce, not increase, vigor. This is particularly so in English, where the native words are short, and long ones are foreign." But only about a fourth of our vocabulary of 600,000 words goes back to native Old English.

Legal jargon makes any plain writing sound stilted, obscure, and unnatural. A few of these offenders are *said, such, aforesaid, prior and pursuant to, thereof, therefrom, hereinunder, herewith, hereunto, wherefrom, wherewith,* and others like them. *Aforementioned, re, in re,* and *anent* are taboo. Anglicized plurals like *memorandums* and *campuses* are better than foreign plurals, and *data* is correct as a singular noun.

Per is Latin for "through, by means of." *As per, per books, per balance sheet,* and *per contract* are nonsense. It's better to say "an hour, a day, or a year" than *per hour, per diem, per annum. Etc.* is incorrect after *and* and redundant after *for example, such as,* and similar phrases. Even *viz., i. e., e. g.,* and other abbreviations are not so good as equivalent English words.

Surely all of us will agree that if all legal documents, insurance policies, and the like could be reworded so that average readers could understand them, we would effect a genuine public service.

Loaded Words

These words are full of dynamite and must be managed with care, if they are ever used at all. The trouble with them is that they do *more* than their job, more than they should; even when their work is not harmful, they can commit a writer or speaker far beyond his desire. They boomerang.

So we need to watch these loaded words because they can "make or break" a sale, deal, collection, or friendship. Charged with implications, they bob up most frequently in communication meant for persuasion and make their employer sound like a propagandist, a hothead, or a radical.

appeaser	obstructionist
capitalist	pessimist
demagogue	predatory rich
dictator	filthy lucre
communist	you must
misinformed	you claim
obligated	your carelessness
nonsense	you misrepresented

Idiomatic Words

Idioms are word groups peculiar to a language but not explained by grammar. Certain words, without rhyme or reason, work only with certain others to communicate a certain message. Established by long usage, they are reputable expressions. For example, we are "determined *to* go" but "bent *on* going."

Using the wrong preposition after certain nouns, verbs, or adjectives is the commonest misuse in managing these word groups. Thus we agree *with* a person, agree *to* a proposal, agree *on* a plan, agree *between* ourselves (two), agree *among* ourselves (more than two), agree *in* part, agree *on* selling, and agree *to* sell.

Again, the word order makes a difference in meaning. Contrast "to see *through* a thing" with "to see a thing *through*." And a man may be an adviser *of, in, for* or *at*—depending upon what words follow.

Those who study any foreign language know what trouble these word groups cause the writer. The only way to use idioms correctly is to learn them one by one, and often our first impulse in using them is instinctively the safest to follow.

Although the number is endless, here are a few idioms that seem to cause a lot of trouble.

abhorrence **of**	could **have** managed
acquiesce **in**	differ **with**
aim **to prove**	different **from**
capable **of** doing	envious **of**
compared **with**	identical **with**
comply **with**	inferior **to**
conform **to, with**	inveigh **against**
correspond **to** that	oblivious **of**

Troublesome Words

By now you may consider all words troublesome, but some are more refractory than others. Every word-manager knows that some look and sound alike but have different meanings. To hold the wrong one off and use the right one, he needs to learn the character of each exactly as he does with human beings.

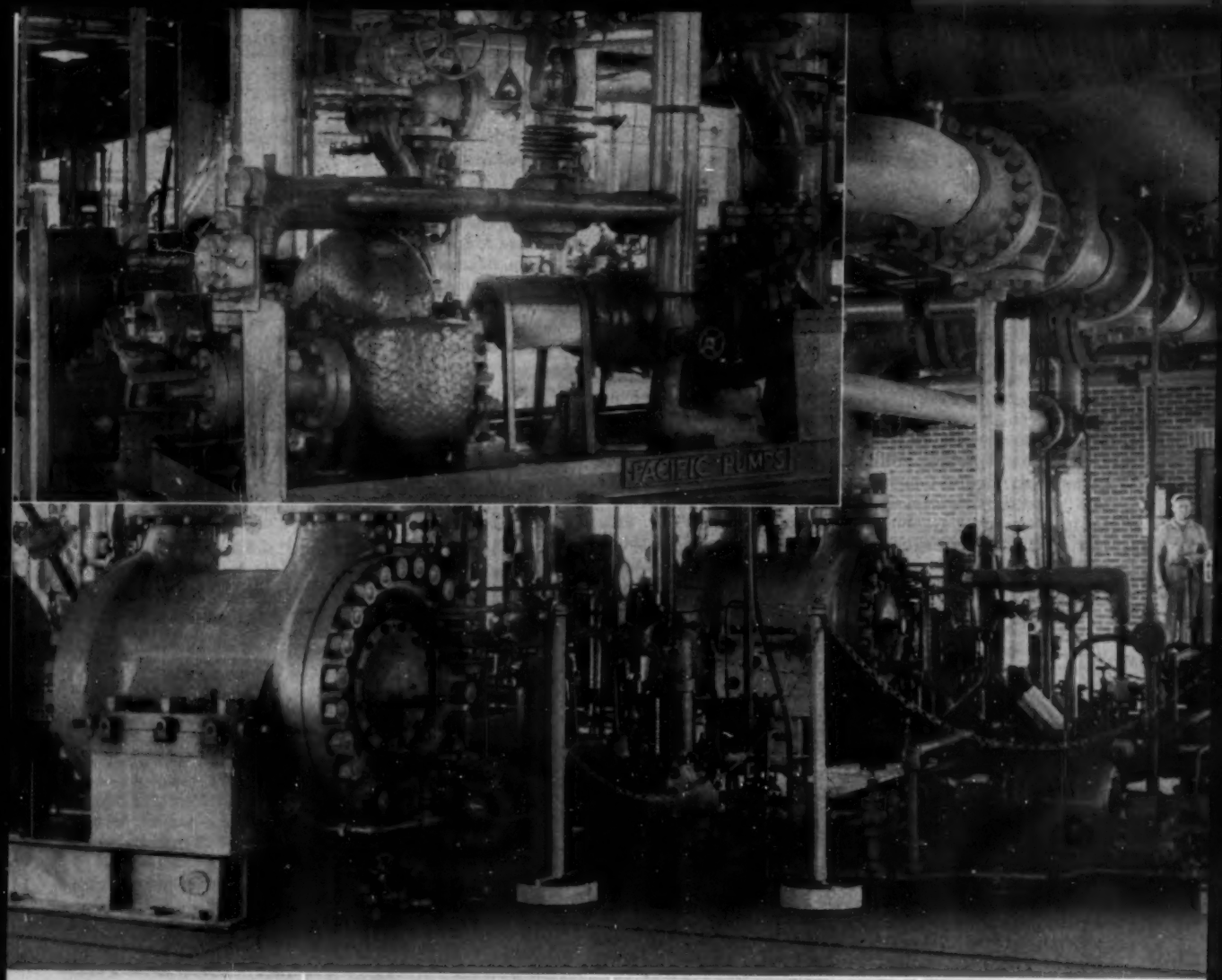
Some of the most confusing ones are simple words: *lie* and *lay, sit* and *set, affect* and *effect, infer* and *imply, liable* and *likely, like* and *as, practical* and *practicable, principle* and *principal, mediate* and *arbitrate.* Daily use of a handy dictionary like *Webster's New Collegiate* will help anyone in the careful management of these words. It's painstaking work that pays off.

Conclusion

Since we **always communicate to somebody for a purpose,** our first duty is to manage our word-workers to get the best results. Effective and efficient communication depends upon our skill in word-management. If we don't get our communication jobs done smoothly and economically, it's our fault as word-managers. The words are here, and each has a service that awaits our command.

Amazingly enough, words resemble human employees in many ways. Some are more active than others by nature. Some words are ambitious, enterprising, timid, retiring, or downright lazy. Others are overbearing, explosive, tired, inexact, or bothersome. Only by learning their background, personality, traits, and capabilities can we become expert at putting words to work.

Perfect communication we may never achieve, but we can certainly improve what now passes for it in the business world. We can produce better letters, reports, memos, brochures, pamphlets, and bulletins through a better management of words. Getting the best brand and greatest amount of work from each word is a richly rewarding experience. From learning how to manage words, we learn better how to master our own jobs—and eventually, let us hope, ourselves and our own lives. ★ ★ ★



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At the upper left, the Pacific pumps are shown in operation moving thousands of gallons of process stock daily.

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A CENTURY CLUB...

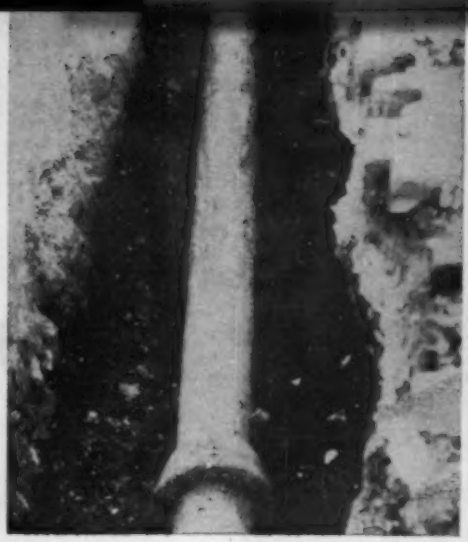
that demands a unique qualification — a cast iron pipe in service more than 100 years

THERE is one very limited club in the United States and Canada. A company has to be in the gas or water distribution business for 100 years or more to be eligible and even that isn't enough. It also has to have a cast iron underground pressure main that has been in active service not less than 100 years.

The Cast Iron Pipe Century Club was organized in 1947 with 18 members — this year there are 72, including the 4 Canadian members.

At present the club members are thick in the far East, with St. Louis and New Orleans as outposts. The great Western Plains and Rocky Mountain inhabitants were still carrying water in buckets for the most part. Sacramento, California, is the lone member in the far West. As the years go by, it will be interesting to see where the club members come from.

Philadelphia, Pennsylvania, claims the oldest cast iron pipe in use in the



This pipe, laid in St. Louis, Missouri, in 1831, is still in service.

MEMBERS OF CIP CENTURY CLUB

	Years of Service
Dept. of Water and Water Supply City of Albany, New York	105
Niagara Mohawk Power Corp. Albany, New York (gas)	104
Alexandria Water Company Alexandria, Virginia	105
Bureau of Water Allentown, Pennsylvania	140
Bureau of Water, Public Works Dept. Baltimore, Maryland	125
Consolidated Gas, Electric L&P Co. Baltimore, Maryland	140
Public Works Dept. Water Div. Boston, Massachusetts	109
Boston Consolidated Gas Co. Boston, Massachusetts	133
Public Service Elec. & Gas Co. Bound Brook, New Jersey	104
Bridgeport Gas Light Company Bridgeport, Connecticut	105
Dept. of Public Works, Water Div. Buffalo, New York	104
So. Carolina Electric & Gas Co. Charleston, South Carolina	118
Peoples Gas Light & Coke Co. Chicago, Illinois	105
Water Works Department Chicago, Illinois	104
Cincinnati Gas & Electric Co. Cincinnati, Ohio	101
Columbia Water Company Columbia, Pennsylvania	127
Board of Water Commissioners Detroit, Michigan	126
Michigan Consolidated Gas Co. Detroit, Michigan	103
Southern Indiana Gas & Electric Co. Evansville, Indiana	102
Fall River Gas Works Co. Fall River, Massachusetts	109
City of Frederick Water Dept. Frederick, Maryland	112
Frederick Gas Company, Inc. Frederick, Maryland	104
Gas Department City of Fredericksburg, Virginia	126
Public Service Commission City of Halifax, Nova Scotia	110

	Years of Service
The Hartford Gas Company Hartford, Connecticut	107
Water Bureau of Metropolitan Dist. Hartford, Connecticut	102
Municipal Water Works Huntsville, Alabama	120
Citizens Gas & Coke Utility Indianapolis, Indiana	105
Bureau of Water Lancaster, Pennsylvania	121
Louisville Gas & Electric Co. Louisville, Kentucky	117
City of Lynchburg Water Dept. Lynchburg, Virginia	126
Natural Gas Service, Inc. Madison, Indiana	105
Municipal Authority of Minersville Minersville, Penn. (water)	101
Mobile Gas Service Corp. Mobile, Alabama	124
Mobile Water Works Company Mobile, Alabama	126
Quebec Hydro-Electric Comm. Montreal, Quebec	140
Public Works Dept. Water-Works Div. Montreal, Quebec	140
Pennichuck Water Works Nashua, New Hampshire	102
Waterworks Department City of Nashville, Tennessee	124
Public Service Electric & Gas Co. New Brunswick, New Jersey	105
New Haven Gas Company New Haven, Connecticut	109
New Orleans Public Service, Inc. New Orleans, Louisiana (gas)	121
Public Service Electric & Gas Co. Newark, New Jersey	110
Dept. of Water, Gas & Electricity New York, New York	132
Philadelphia Elec. Co., Gas Dept. Norristown, Pennsylvania	104
City of Painesville, Gas Dist. Dept. Painesville, Ohio	111
Central Illinois Light Co. Peoria, Illinois	103
Public Works, Bureau of Water Philadelphia, Pennsylvania	134

	Years of Service
Philadelphia Gas Works Co. Philadelphia, Pennsylvania	121
Bureau of Water, Public Works Pittsburgh, Pennsylvania	106
Plymouth Gas Light Company Plymouth, Massachusetts	103
Pottsville Water Company Pottsville, Pennsylvania	122
Providence Gas Company Providence, Rhode Island	104
Quebec Power Company, Gas Div. Quebec, Canada	109
Bureau of Water Reading, Pennsylvania	122
Dept. of Public Utilities (gas) Richmond, Virginia	105
Dept. of Public Utilities (water) Richmond, Virginia	126
Rochester Gas & Electric Corp. Rochester, New York	103
Division of Water & Sewers Sacramento, California	102
Water & Sewerage Dept. City of Saint John, New Brunswick	112
Dept. of Public Utilities, Water Div. St. Louis, Missouri	125
North Shore Gas Company Salem, Massachusetts	106
Central Illinois Light Company Springfield, Illinois	103
Water Division, Dept. of Engineering Syracuse, New York	104
The Consumer's Gas Co. of Toronto Toronto, Ontario	114
Dept. of Public Works Troy, New York	111
City of Utica, Water Supply Utica, New York	107
City of Wheeling Water Dept. Wheeling, West Virginia	122
Wilmington Water Dept. Wilmington, Delaware	129
Water Department City of Winchester, Virginia	130
Water Department City of Winston-Salem, N. Car.	114
York Water Company York, Pennsylvania	116
Water Department City of Zanesville, Ohio	111

In New York City is the above cast iron pipe 126 years old.

Boston, Massachusetts, has this pipe in service since 1847.

United States — it was first laid 134 years ago. Boston, Massachusetts, has a 133 year old main in use and New York, a pipe 132 years in service. Montreal, in Canada, has an older record — 140-year cast iron pipe in service.

The table gives the names of the member companies, which can be municipal or privately owned, their location, and the number of years their oldest cast iron pipe has been in service.

The Century Club was organized by Thomas F. Wolfe, managing director of Cast Iron Pipe Research Association. Like nothing else could, the exclusive club points up the sturdy qualities of cast iron pipe. After all, when a product is in use from 100 to 135 years in 60 different towns, it is pretty obvious that it doesn't wear out easily.

It is an honor for the members who can show with modesty the Certificate of Membership in CIPCC, which indicates the company is not a fly-by-night organization either. ★ ★ ★

Dallas Section of AIME Petroleum Conference Set

A petroleum conference on economics and valuation will be held in Dallas March 29-30 at the Staler-Hilton Hotel.

The conference is being sponsored by the Dallas Local Section of the American Institute of Mining, Metallurgical, and Petroleum Engineers. Carl E. Reistle, Jr., production vice president of Humble Oil and Refining Company and president-elect of AIME, will speak on "The Application of Engineering Valuations in Management."

The Dallas Local Section, AIME plans to publish all papers in a bound booklet for distribution to all who register for the meeting. Preregistration or purchase of the bound booklet may be accomplished by writing A. B. Dyes, Box 2819, Dallas, Texas. R. F. Madera, Republic Natural Gas, is meeting chairman, and Gene E. Roark, James A. Lewis Engineering, Inc., is program chairman.

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OVER the last ten years there has been a slow but steady surge toward decentralization of management — until today, almost without our realizing it, the structure of business has undergone a radical transformation.

This does not show up just as geographic dispersal of plants — although distance from the home office does increase both the need and the opportunity for decentralized management. And there are not always big changes on the formal organization chart — although many of the names and titles that appear there would have no real meaning if decentralization were not the underlying management philosophy.

What really counts is decentralization of *responsibility* — making divisions or departments in effect independent operating units, whether at the same location or not; and giving the heads of those units freedom to make their own decisions, no matter how solid or straight the lines that run from them to their superiors on the chart.

Wherever such a move has been made, the results have usually been dynamic. The reason is simple: men are most likely to perform to their full potential when they are "on their own" — when they are challenged and self-motivation comes into play.

But, by the same token, the dynamic effects have not always meant progress or even smooth sailing for the company as a whole. One of the corollaries of decentralization, which often gets overlooked, is that along with freedom to make decisions must come stronger and surer controls to avoid faulty decisions or decisions that run counter to the overall interests of the company. There is no profit in everyone working furiously at cross-purposes; the individual sources of energy released by decentralization must be harnessed together.

Also, the very fact that decentralization does seem to provide gold without digging has caused it to be accepted too easily. Many managements in their enthusiasm have neglected to explore for any richer veins. Certainly it should be worth more if mined carefully.

Increasing the Payoff

Some of the steps that must be taken to increase the payoff of decentralization are worthwhile in their own right. If they would not have been started otherwise, then that is simply one more benefit to be credited to decentralization.

First of all, decentralization will be only a pale shadow of what it could be if there is no planning of objectives or setting of goals — and not just for the company as a whole, but for individual operating units. In fact, this factor often determines the extent to which decentralization can be carried. If the operating unit cannot be assigned some specific contribution that it is expected to make to the overall results of the company, then it is too small to be given independent responsibility.

Even more important, the heads of the decentralized units must be capable of carrying responsibility, and their superiors must be capable of delegating it to them. Of these requirements, that of delegation is probably the tougher. It means a change in management behavior from always deciding what to do to letting others make decisions (even when you know you could do it better); from being a commander to acting as a developer and coach of people (which takes tremendous patience in the face of pressure for results).

It is inevitable that a manager will incur mistakes if he is free to make decisions affecting the division or department he heads. But unless he has that freedom — and *feels* it — there will be no dynamic effect. Selection and training of managers therefore become more important than ever: the better the man, the less likely he is to make mistakes. Careful formulation of policies and procedures also become increasingly necessary: the more he knows what he is supposed to do, the less likely he is to take the wrong course.

The fact remains that the manager's superiors, often the top officers of the company, must steel themselves to expect less than perfection . . . and then do everything they can to help him perform perfectly. Here budgets and other forms of control can be brought to bear. If properly applied they will increase the man's real freedom, for they will be definite guides to him as well as reassuring safeguards to his superiors.

Control Devices

The surest way to emasculate decentralization is for the superior to say "you are free to make mistakes" and then to watch every decision so closely that the man has no chance to be wrong. Control devices have the advantages of being impersonal and objective. Also, by being set up ahead of time, they tell the man how far he can go rather than that he must stop here and turn back. They can be positive, as well as negative; indeed they must be felt as primarily constructive, or they will have a deadly, dampening effect.

From Acme Reporter, official publication of Association of Consulting Management Engineers, Inc.

The budget, one of the most common control devices, unfortunately labors under the handicap of bad connotations. In private life and in business, the budget has been misused so often as a whipping post that people instinctively react against it. However, this unfavorable attitude can be overcome by such steps as the following:

(1) Having the manager who must conform to a budget participate in its planning — so that he considers it his own, rather than something imposed on him. Incidentally, both the individual division and department budgets and the overall budget of which they are components should be much sounder as a result of thus tapping first-hand knowledge of conditions in the operating units.

(2) Treating the budget as a plan of action expressed in dollars rather than as a device to limit expenditures. To this end, the budget should, as far as possible, consist of those items that reflect the manager's decision making. It follows that the manager must understand the meaning of all the budget items and the relation of his actions to them. If too many external and arbitrary items, like allocated costs, are included, the manager will not feel he has much to do with achieving the planned results.

(3) Keeping the manager informed of his progress in reference to the budget. This way he will know that he is on the right course; or have time to bring results into line, rather than suddenly be faced with a situation where the only solution is to sacrifice some needed activity. Even more important, this way the budget will serve to set the direction of the manager's decision making.

(4) Handling the budget with some degree of flexibility. The tendency is to leave the budget alone once it is set at the beginning of the year, unless and until it becomes clear that the manager is unable to meet it — and then to clamp down on him drastically. Such crises are avoided when there are formal checks on progress at periodic intervals, with revisions to meet changing conditions. Revisions should not always be downward, either. There is no better way to unleash the initiative of the manager than to convince him that he will have more to spend for his unit if he can justify it by producing better-than-expected results.

Another common control device particularly appropriate in large companies, is the internal audit — a staff activity that watches and probes the operators of the decentralized units. The staff representatives ideally do not give the impression of being policemen; they work closely with each manager, callings his attention to areas where he is

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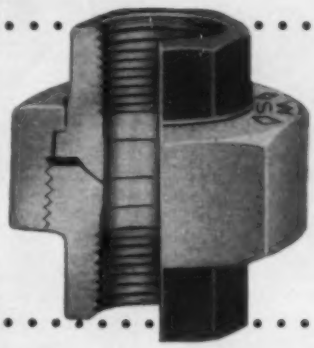

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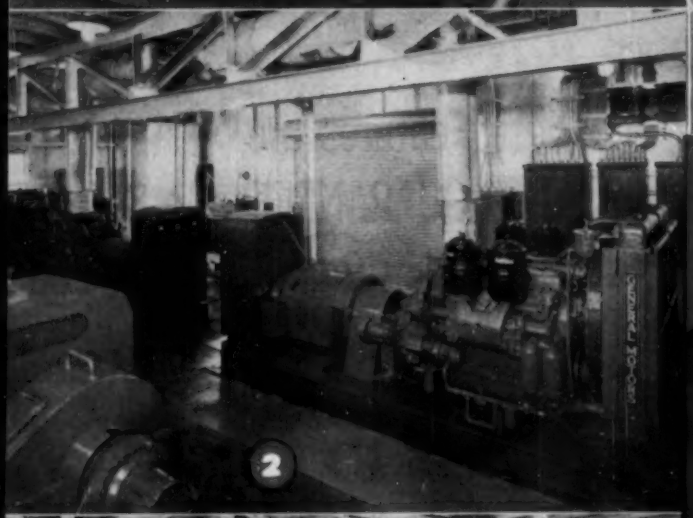

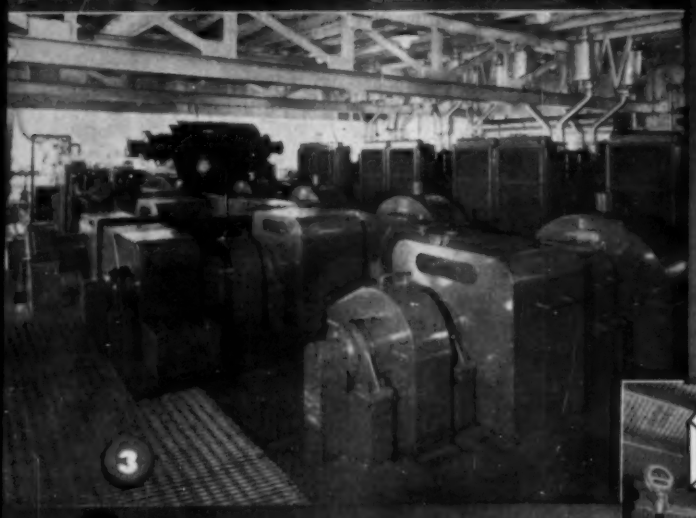

out in the gulf

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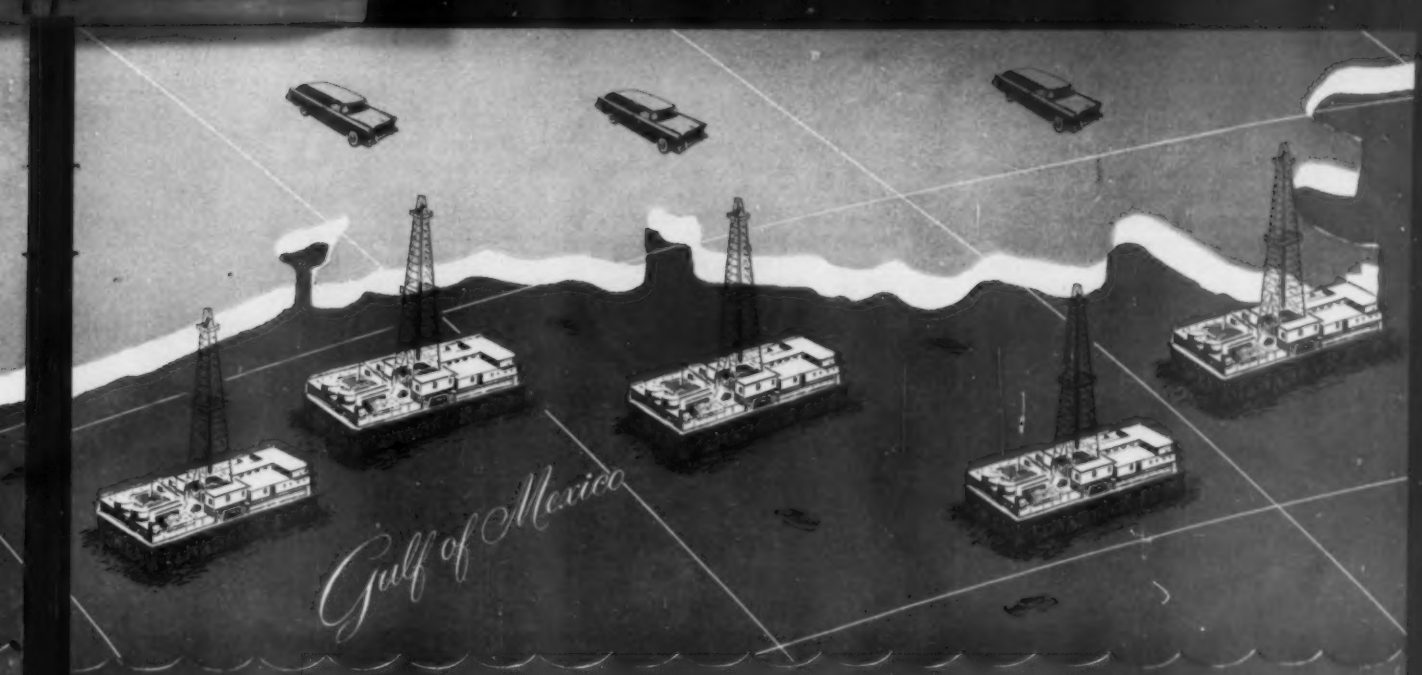
1 Three Model 645 quad engines with a rated continuous horsepower of 525 each power a Southeastern Drilling Co. barge. A 645 Diesel twin 260 continuous horsepower engine powers the 7¼" x 14" mud mixing pump on the rig and the two light plants are each powered by a single 645 Diesel 6-71 engine.

2 Electricity on the "Mr. Gus" is supplied by four Model 12-GB149 Stewart & Stevenson Diesel Generator Sets.

3 The drawworks and compound on the "Mr. Gus" are powered with four Model 24103 General Motors Diesel Quad Units from Stewart & Stevenson.

4 Here is a typical mud pump application using the 625 continuous horsepower Model 567-C General Motors Diesel Engine to drive an Oil Well 20 P mud pump.

*Glascock Drilling Co.



WHERE SERVICE and DEPENDABILITY REALLY COUNT

GM DIESEL BY STEWART & STEVENSON

IS FIRST CHOICE

From the start of the extensive offshore drilling program back in 1947 right up to the recent dedication of the "Mr. Gus,"* more offshore drilling rigs operating along the Gulf Coast are powered with General Motors Diesel Engines by Stewart & Stevenson than any other make.

Today when you seriously consider all of the factors, there are more reasons for selecting power from Stewart & Stevenson than ever before.

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1. **New and Wider Choice of Power Selection.** With the addition of the larger Series 567C line of Diesel and dual fuel engines, Stewart & Stevenson offers a complete range of drilling engines up to 1750 HP each.

2. **Diesel Electric Drive.** The new 567C Diesel electric drive units available from Stewart & Stevenson offer the acknowledged superiority, flexibility and dependability of Diesel electric drive at low initial costs.

3. **Engineered Installation.** Stewart & Stevenson engineers recommend the best engine for the purpose. Our factory is available for the design and fabrication of the substructure, drives, and other necessary auxiliaries and our factory-trained engineers make sure the engines are properly installed.

4. **Guaranteed Performance.** Stewart & Stevenson engineers and factory-trained servicemen are on the location making sure that the installation is complete and the engines operating at top efficiency.

5. **Parts and Service Responsibility.** A factor of utmost importance in making GM Diesels first in offshore power is the attitude of Stewart & Stevenson in assuming full parts and service responsibilities. We believe in the statement that "engines are no better than the parts and service organization behind them" and actions are guided accordingly. When you deal with Stewart & Stevenson you can be sure that if and when service problems should develop, Stewart & Stevenson will assume the full responsibility for their correction and will provide the materials, services and experience to correct them.

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STEWART & STEVENSON SERVICES
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THE NATION'S LARGEST DISTRIBUTOR OF GM DIESEL ENGINES

slipping behind budget or at variance with company policy and thus giving him an opprtunity to take corrective action on his own. Nor should they be considered stool pigeons; while they must report back to superiors the conditions they find in each unit, they can usually avoid any negative reactions by going over their reports with the manager before final submission and incorporating mention of the steps which the manager himself has decided on.

Whether this device or any other is used, the essential point is to have control in the sense of being "on top of things" — knowing how performance is meeting company objectives and policies, and being able to step in to take care of unusual or unexpected developments — not in the sense of restricting or cramping managers in their day-to-day activities.

Staff Assistance

To give a manager true responsibility means that he will be making all the decisions that are called for in the operation of his unit. Inevitably there are many occasions where matters affecting the company as a whole are involved — for example, wages and hours of work in a unionized company — and the manager's decisions must be made in line with overall company policy. There will be even more occasions where the decisions to be made require technical skills such as no manager could possibly be expected to possess in full—for example, legal knowledge, personnel techniques like psychological testing and job training, methods engineering, and so on.

Therefore, the manager needs to know clearly what company policy calls for, and he needs to have specialized assistance in technical matters. This will actually increase his freedom to make decisions. Although the area in which he can use his own unaided judgment may be a little narrower, his depth of responsibility will be greater because he can be better trusted to make sound decisions. Not only can he be left alone more safely. Also, knowing that he will not be out of line with company policy and that he will not be making technical mistakes, he is more likely to develop independence and self-confidence to proceed on his own initiative—which is the essence of the dynamic force released by decentralization.

This is why the staff function is so important in decentralized companies. So that the managers of the operating units will be able to apply company policy, it must be spelled out in the form of manuals and standardized procedures. Technical assistance must be provided in such a way that it will be accepted by managers who, not being specialists themselves, will often fail to understand either the techniques involved or the reasons why they are necessary.

Obviously, if a manager is simply told that he is to follow such and such a procedure, his feeling of independence will be thereby diminished. Even little matters are important, for a series of negative reactions can build up to the wrong attitude, and attitude is what counts when you are seeking the energizing force of self-motivation. Of course, no manager can expect to agree with every suggestion or directive from his superiors; but if he agrees with most of them, he will take the balance on faith—and, in turn, his attitude will be communicated to his subordinates.

Accordingly, the ideal staff man never gives orders, but endeavors to show the manager that his advice is so useful that it is worth following at all times. Like the internal auditor, he works closely with the manager as a collaborator counselor, not as an interfering busybody; and the manager goes on making his own decisions.

Standards of Performance

Since this philosophy depends on men as managers rather than on followers of orders from above, it is imperative that there be constant appraisal of their individual performance in terms of the results they achieve for the units they head. Only in this way can the strong men be encouraged and the weak men helped.

Here is an aspect of decentralization that is often neglected. Many companies simply leave it to the judgment of superiors. Aside from the fact that such judgment can be swayed by personal bias and often is superficial if not downright wrong, the manager himself needs something more tangible and concrete. If he is doing a good job he should have assurance that the fact is appreciated and it is worthwhile for him to continue and to do even better. If he is doing a poor job, he should be able to know on what grounds his performance is considered deficient and so can try to improve it.

Ideally, each unit should have its own profit-and-loss statement. That measures, as nothing else can, the unit's contribution to the overall results that the company is seeking. But it is not always realistic to do so—for example, if the dollar results are influenced by decisions made elsewhere in the company, or there is no sound way to price intra-company transfers into or out of the unit—and if it is not realistic, it will lose its constructive effect if not actually cause bewilderment or resentment.

So it may be necessary to settle for some other measuring rod like sales or productivity or return on investment. The essential point is to have some way of appraising the performance of the department or division that can be expressed in quantitative terms, will be meaningful to the managers, and reflects the decisions made within the particular unit.

Many companies have found that if they tie the manager's personal earnings in with the results of his department or division, they get a tremendous incentive effect similar to that of the owner of a small business. The success of such compensation plans obviously depends on the soundness of the measurement of performance. To be justifiable from the standpoint of the company and its stockholder, it must really gage the managers contribution to the total effort of the company; and to be effective from the standpoint of the manager, it must be directly related to the quality of his own managership.

Full Potential

Decentralization poses an unusual combination of simplicity and complexity. The principle is so straightforward: As business organizations grow bigger and more cumbersome, the way to get spirit back into the lower layers of management is to give them responsibility for running their units almost as if they were individually owned businesses. But the implementation is so difficult: After all, these operating units are parts of a total organization, so the more freedom you give them, the more you must guide them, control them, and help them.

Any company can get more drive into its operations by delegating more responsibility. But that is easier to say than do; it requires a change in management behavior that many presidents and top officers of companies find hard to make—and to persevere in even after they think they have made it. Moreover, there are so many complicated problems to solve, and so many unfamiliar steps to take in order to get full value out of decentralization, that no company should undertake it lightly, without careful planning and consultation with someone who knows the experience of companies that have already been "through the mill."

Also, in view of the foregoing discussion, it should be clear that for many companies which have already embarked on a policy of decentralization, there are probably many improvements or further steps they could take to realize the full potential value of this philosophy of management, again through careful planning and consultation. ★ ★ ★

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Lowest Cost Per Horsepower Installed

THE COTTON VALLEY OPERATORS COMMITTEE is adding these two Beaird-Ingersoll-Rand 6SVG 330 Horsepower Packaged Compressors to its Justiss Reservoirs Pressure Maintenance Station. Located six miles from the cycling plant, the station was initially equipped with one Beaird 300 horsepower packaged compressor.

When the new units are placed on the line, the enlarged station will handle 24 mmcfd. Residue gas from the main plant will be picked up at 2000 psig and boosted to 4000 psig for injection into the reservoirs. As field operating conditions change, CVOC personnel will install new outer head plugs furnished with the units. The station will then be capable of compressing 29 mmcfd from 2500 psig to 4300 psig.

This on-the-job modification to the compressors will permit the production of the reservoirs to their final stages without compressor cylinder change. No additional operating personnel will be required as the units have been equipped with automatic controls that permit their unattended operation except for scheduled maintenance. Highly salvable, the entire installation can be moved to other service when the Justiss Reservoirs are depleted.

Let us show you how Beaird-Ingersoll-Rand packaged compressor plants can be designed to meet your special requirements.

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PACKAGED COMPRESSORS FOR RESERVOIR PRESSURE MAINTENANCE

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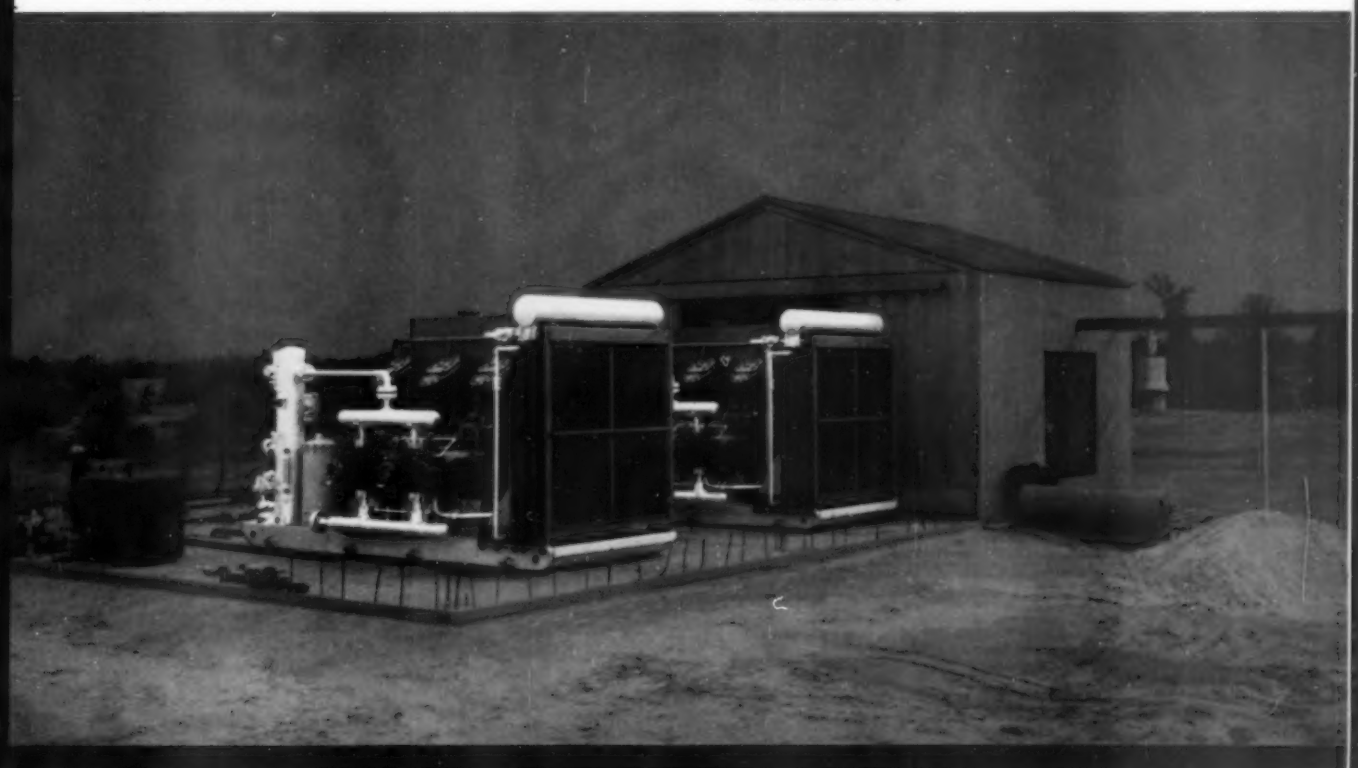

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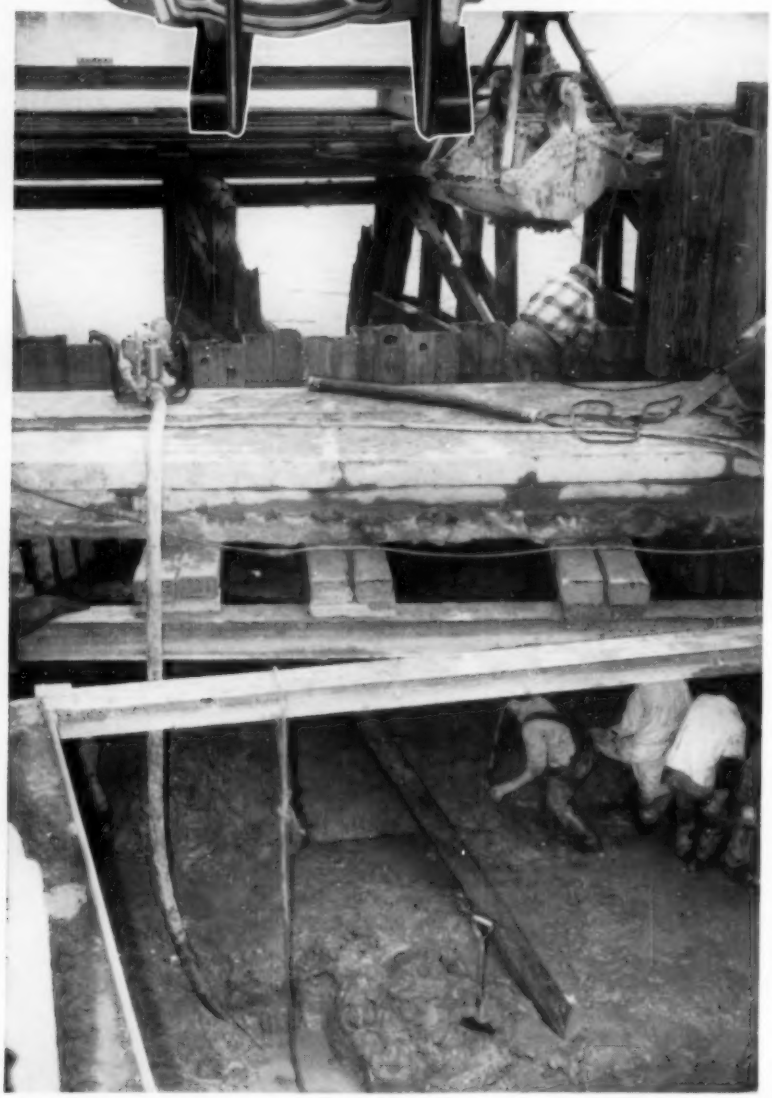

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Write or call your nearest Homelite representative for complete information or a free demonstration.

**120 pounds for easier carrying*

Model 20DP3 has guaranteed suction lift up to 28 feet and total head up to 50 feet, including friction.

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LAUGH with BARNEY

She: I think men should wear something to show they're married. Women wear wedding rings.

He: Men wear something to show they're married. They wear last year's clothes.

A retired farmer moved to the city. On the first morning in their new home his wife said, "Pa, it's time you got up and started the fire."

"Not me," he exclaimed. "We might as well start right now getting used to all the city conveniences. Call the fire department."

The maharajah of an interior Indian province decreed that no wild animals could be killed. Soon the country was overrun by man-eating tigers, lions, panthers and boars. The people could stand it no longer and gave the maharajah the heave-ho. And this was the first instance on record where the reign was called on account of game.

A colonel was transferred to a new command. On reaching his depot, he found stacks of old documents accumulated in the archives of his predecessors, so he wired headquarters for permission to burn them. The answer came back: "Yes, but make copies first."

Luke called his landlady Lifebuoy — everybody odor!

Raising funds for a new church, the ingenious church treasurer "wired" all the pews in the old church so that when the minister asked for all who would give $1,000 to please stand up, he pressed the $1,000 button — and about 50 members were shocked right up on their feet. He worked the same scheme for $500 donations, then $400, $300, and on down. When the preacher was telling about it later, another preacher friend remarked: "Well, I suppose your drive was a success?"

"Oh, yes," replied the first minister, "we oversubscribed our goal. But there was one sad note. The Widow Brown, Banker Jones, and two of our deacons were electrocuted."

Grandma Jones had lived alone in her cottage for many, many years. She seldom ventured farther than the front gate and that was only to get mail. She seemed, however, to enjoy her life of solitude.

"But, how do you stand the everlastin' silence, Grandma?" asked one of her neighbors one day.

Grandma looked fondly at those two kittens that were playing with a ball of twine on the floor. "Oh," she said with a playful gleam in her eye, "when it gets so quiet that I can't stand it any longer, I just kick hell out of one of the cats."

Professor (finishing long algebra problem): And so we find that X equals zero.

Sophomore: All that work for nothing.

The most disappointed people in the world are those who get what is coming to them.

According to a story going the rounds in Western Europe, one Prague resident refused to join the general outcry against a new Stalin statue in the city's square.

"Why not?" he said. "It will give us shade in summer, shelter in winter, and opportunity for the birds to speak for all of us."

After a very trying day at the office, the husband was enjoying his pipe and reading the evening paper. His wife, who was working on a crossword puzzle, suddenly called out, "John, what is a female sheep?"

"Ewe," replied her husband. And that's how the fight began.

It's generally the hole in a man's pocket that keeps him broke—the one at the top.

A woman is young until she takes more interest in how her shoes fit than her sweater.

A new word has been added to our American vocabulary. In describing a boy of his acquaintance, a youth said, "He's psychoceramic."

"What's that?" someone asked.

"Crackpot."

The arm of a well-dressed, generous-looking passerby was clutched by a beggar who whined, "Give me five cents, kind sir, for a cup of coffee?"

The other looked him over carefully. "Why should I give you five cents?" he asked.

"Because, sir, prior to my terrible catastrophe, I, too, enjoyed business success and prosperity," was his reply. "I was an industrious worker. On the wall above my desk I had a motto which read, 'Think Constructively — Act Decisively.' The money poured into my coffer. And then . . . and then . . ."

"Yes? What happened?"

The beggar's frame shook conclusively. Tears appeared in his eyes.

"The cleaning lady burned my motto."

Th' feller that sets on a store box with his mouth full of chawin' terbackker while his wife is at home sewin' fer a livin' knows jist exactly how t' regulate the railroads.

"The eggs are very small," complained the young housewife to her grocer.

"Straight from the farm this morning, madam," declared the grocer.

"That's the trouble with these farmers," she persisted. "They are so anxious to get their eggs sold they take them off the nest too soon."

Grocer: You want a pound of orche? Is it red ochre for painting bricks?

Small Boy: No, it's tappy ochre wot Ma makes puddin' with.

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Carryable
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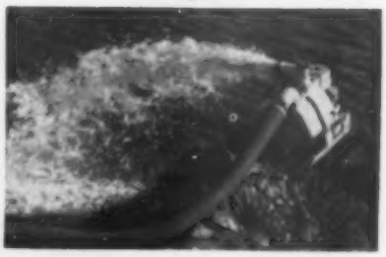

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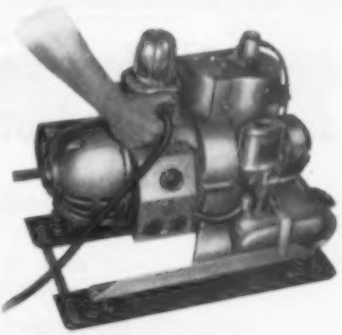
Sizes: 1½" to 3" — capacities to 15,000 g.p.h. for dewatering and water supply.



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LIGHTWEIGHT POWERFUL ONE-MAN CHAIN SAWS;
Complete line of saws with clearing and brushcutter attachments for every woodcutting job.

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digs 17¾ feet deep . . . dumps at 8¾ foot height

With its long, deep reach, Koehring ½-yard 205 hoe digs 17¾ feet below grade . . . has 8′ 9″ clearance height at beginning of dump to load trucks. Maximum cutting width, with side cutters, is 31 inches. During the hoist-and-swing cycle, close-coupled dipper pulls up tight to boom, avoids spillage. Powerful cable crowd, fast line and swing speeds maintain big-yardage production. Heavy-duty, box-section boom and dipper arm resist side-sway in toughest digging. Operators like the 205's ease of operation . . . *you'll* like its EXTRA WORK CAPACITY. Here are some of the heavy-duty advantages you get that increase production with every 205 attachment:

Big 20-inch main drum clutches.

Only 2 major shafts in upper machinery . . . simple, accessible.

Heavy-duty splined shafts . . . carburized, hardened gears.

4 hook-rollers, eccentric adjustment.

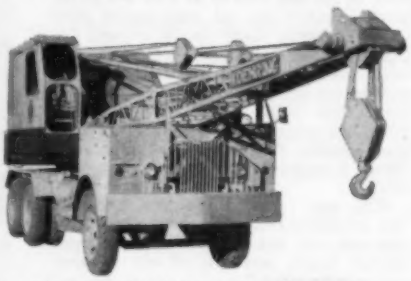
Automatic crawler traction-brakes.

Standard or extra-long crawlers . . . with 16, 20, or 24-inch shoes.

Independent traction . . . optional.

Antifriction power-flow for dig, hoist, swing, travel.

Crawler-mounted 205 brings you: ½-yard dipper capacity as a shovel or hoe . . . ½ to ¾-yard bucket capacity as a clamshell or dragline . . . 10-ton lift crane.



Truck-mounted 205 has 15 tons lift capacity, 25 to 55-ft. boom, plus max. 30-ft. jib. Travels 32½ m.p.h. Converts to all standard excavator, crane attachments.

Get the complete story on this new 205. Ask your Koehring distributor for details, or write for bulletin.

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BOOKS ★

Pipe and Tube Bending, *Paul B. Schubert, published by The Industrial Press, 93 Worth Street, New York, New York. Price $5. Pages, 183.*

A long-felt need for a practical working manual that describes and illustrates common methods of bending both ferrous and non-ferrous pipe and tubing is answered with publication of this book. In addition to useful data and pointers for both shop and field men, the book describes the machines, fixtures, and devices needed and used. An entire chapter is devoted to pipe layout for bands and gives formulas used for various degrees of bend and data on minimum radii for bends. Illustrations and diagrams are plentiful, and 15 helpful tables add to the book's value.

Oil and Petroleum Year Book, *compiled and published by Walter E. Skinner, 20 Copthall Avenue, London, E. C. 2, England. Pages, 360. Price, $5.00.*

Forty-sixth issue of this reference volume, compiled by Walter E. Skinner, has just been published. Information on some 970 companies covering all branches of the oil industry, with a list of names and addresses of 663 managers and engineers and company affiliations are listed.

Book contains information on the principal British, American, Canadian and foreign companies. Particulars of each company includes names and directors and other officials, description of business, where operating, crude oil production, refinery runs, details of capital, dividends and financial results.

A buyers' guide of manufacturers of oilfield and refinery equipment comprises 883 headings.

Engineering Standards Multiple V-Belt Drives, *published by the Multiple V-Belt Drive and Mechanical Power Transmission Association, 27 East Monroe Street, Chicago 3, Illinois, and The Rubber Manufacturers Association, 444 Madison Avenue, New York 22, New York. Pages, 24. Price, $1.00.*

This manual records the technological improvements in V-belts since the first edition of this standard was issued in 1951. Greater belt strength has been attendent with higher horsepower ratings, prompting the technical committees of the two associations to revise this datum.

Information in the manual is based on recent engineering opinion and research, and indicates the proper sheaves and belts to be used for the attainment of optimum efficiency and economy of the drive with relation to the particular duty to be performed.

Basic changes in the revised manual include ten (10) pages of new horsepower ratings. The new manual shows ratings for belt speeds from 200 to 6000 feet per minute. The basic horsepower formulas used in obtaining the new ratings are shown, taking into consideration drive ratio as well as belt length.

Geology, Principles and Processes, *by William H. Emmons, George A. Thiel, Clinton R. Stauffer, and Ira S. Allison, published by McGraw-Hill Book Company, Inc., 330 West Forty-Second Street, New York 36, New York. Pages 638. Price, $6.50.*

This is the fourth edition of an already well-accepted book, retaining the major plan of organization of earlier editions but with major changes in several sections. The volume is basically an analysis of materials of the earth, the processes which shape its external features, its movements and their results, and its mineral resources.

New material included in this text are a more complete presentation of chemical weathering, a new chapter on the work of the wind, an expansion of erosional processes in desert environments, a discussion and classification of soils as well as a presentation of new concepts regarding the mobility of rocks in relation to mountain building and additional data on the origin and geological setting of nonmetallic mineral resources.

Petrographic Mineralogy, *by Ernest E. Wahlstrom, published by John Wiley & Sons, Inc., 440 Fourth Avenue, New York 16, New York. Pages, 408. Price, $7.75.*

Information necessary for the identification and classification of minerals and rocks under the polarizing microscope or various other petrographic methods is supplied in this new volume.

The book offers explanations of techniques, gives descriptions of minerals as they are seen under the polarizing microscope, furnishes tables for use with the petrographic microscope, and provides condensed summaries of rock classifications. This comprehensive review therefore combines theory and practice to an extent not previously realized in the literature.

Miocene Equidae of the Texas Gulf Coastal Plain, *by James Harrison Quinn, published by the Bureau of Economics Geology, The University of Texas, Austin 12, Texas. Pages, 102. Price, $1.75.*

This paper presents results of a study of fossils of Miocene age from the Texas Gulf Coastal Plain and indicates that current ideas concerning the ancestry of *Equus* and the phylogeny of the hypsodont horses must be revised. Four faunas constituting a new faunal province are named — Garvin Gulley faunda, Oakville formation; Burkeville fauna and Cold Spring fauna, Fleming formation; Lapara Creek fauna, Lapara member of the Goliad formation.

Most of the collections used in the study were collected by a Statewide Paleontological and Mineralogical Survey project. The paper includes a discussion of phylogeny and evolution, and in tabular form shows the areal distribution of the fossil faunas.

Also included are 14 heliotype plates illustrating upper and lower molars and premolars and jaw fragments of these Miocene horses as well as the skull of *Eoequus wilsoni* Quinn, n. gen. and n. sp. The publication is bound in paper cover.

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PERSONALS

▸ **G. L. Knox,** president of The California Standard Company, Calgary, Alberta, has been named chairman of the board of governors of the Canadian Petroleum Association. Other members of the board will be **R. C. Brown, C. U. Daniels, Bart W. Gillespie, Paul L. Kartzke, E. D. Loughney, Vern Taylor, R. A. Bishop, V. H. Hunter, C. E. Leach** and as ex-officio members, **G. E. Dunlap, T. W. G. Thomson, R. A. Cruickshank** and **D. M. Tyerman.**

▸ **Charlton H. Lyons,** Shreveport, Louisiana, is the new president of the Mid-Continent Oil & Gas Association, succeeding **Robert H. Windfohr,** Fort Worth, Texas. Lyons is a former president of the Louisiana-Arkansas division of the association and also of the Independent Petroleum Association of America. Newly elected as area vice presidents are **French M. Robertson,** Abilene, for Texas; **L. Lee Welsh,** Vincent & Welsh, Lake Charles, for Louisiana; **E. L. Branini,** Vicksburg, for Mississippi, and **David R. Stewart,** Moses & Stewart, Mattoon, for Illinois.

▸ **John W. Hancock,** president of the Hancock Oil Company has been elected president of the Western Oil and Gas Association. Hancock succeeds **Charles S. Jones,** president of Richfield Oil Corporation, who served as association president for two years. Other officers elected are **S. F. Bowlby,** vice president, Shell Oil Company, first vice president; **Olen Lane,** vice president, Continental Oil Company, second vice president; **T. H. Wallace,** vice president, Western Gulf Oil Company, treasurer, and Felix Chappellet, association vice president and general manager. Newly elected directors were: **H. D. Campbell,** president, Franco Western Oil Company; **E. B. Hall,** president, Drilling and Production Company; **James T. Wood, Jr.,** vice president, The Texas Company; **John A. Woodward,** president, St. Anthony Oil Corporation.

▸ **William C. Kneale,** Houston, Texas, has been named a director of Rimrock Tidelands, Inc., Shreveport, Louisiana.

Newly elected officers of the Tulsa Chapter of Oklahoma Society of Professional Engineers discuss the chapter's plans for the state convention in Tulsa February 23-25 and for National Engineers Week February 19-25. Front row left to right are M. T. Nigh, executive vice president; W. R. Clarke, president, and L. T. Bossard, outgoing president. Back row left to right are M. J. Myers, Jr., secretary treasurer; and vice presidents, F. M. Bartlett, meetings and programs; C. M. Gordon, Jr., public relations; M. J. Peterson, membership.

▸ **Seth W. Candee,** Plainfield, New Jersey, employee relations supervisor of Tide Water Associated Oil Company's eastern division since 1936, has retired after having served 30 years with the firm. Candee joined the company in 1925 as head of the personnel and industrial relations department with the original Tide Water Oil Company.

▸ **Walter Henry Nelson** has been appointed editor of the API Quarterly. A member of the information department of the American Petroleum Institute staff for the past year, he succeeds **Miss Eloise Michel,** who has retired. Assisting the new editor will be **Edward D. Mellinger,** another departmental member, who has been appointed consulting editor.

▸ **Lord Strathalmond,** chairman of the board of directors of The British Petroleum Company, plans to retire from his post March 31. On that date, he will have completed 33 years of service as a director of the company, for 28 years of which he will have been chairman or deputy chairman. **Basil R. Jackson,** present deputy chairman and **Neville A. Gass,** deputy chairman as of April 1. **The Hon. Maurice Bridgeman** will be named as a director to fill the vacancy on the board resulting from Lord Strathalmond's retirement. Jackson was made a director of British Petroleum in 1948, prior to which he had spent a total of 15 years as manager of the company's New York City office.

▸ **Francis J. Himbury** has been appointed manager of public relations of Canadian Oil Companies, Ltd. He has been associated with the company since 1939 and prior to his new appointment was assistant to the president.

A. C. Rubel, president of the Petroleum Club of Los Angeles, California, recently honored the founding directors and past presidents of the organization with a luncheon in the club quarters and presented each with a scroll of tribute for his good work. Among those present were, seated left to right, J. C. Kelley, Rollin Eckis, David S. Day, Rubel, L. L. Aubert, Mortimer Kline, Henry Salvatori and J. G. Leovy; standing left to right, Gordon Campbell, Tom Sherman, Tom Wallace, Olen Lane, Peg Whealton and Dick Sherman.

T. G. Schad

V. W. Fletcher

T. G. Schad, formerly purchasing agent, has been assigned to a new position as executive assistant to the vice president in charge of the materials department of Asiatic Petroleum Corporation. He has been actively engaged in purchasing activities with Asiatic since 1920 and was appointed purchasing agent in 1945. Schad will be succeeded by **V. W. Fletcher,** who has been associated with Asiatic since 1950. **A. Nilsson,** who joined Asiatic in 1928, has been appointed assistant purchasing agent to succeed Fletcher.

Robert O. Lewers has been appointed division general attorney for Sun Oil Company's Rocky Mountain division. He was made attorney in 1952. Lewers attended Denver University and Regis College, and received his LLB degree from Westminster School of Law, Denver, Colorado.

Ross W. Cummings, former WKY-TV newsman, has been named director of information and public relations for Kerr-McGee Oil Industries, Inc. With WKY-TV news bureau, his television name was Reed Connolly. Cummings attended the University of Oklahoma.

H. W. Penterman, executive assistant to the vice president of Shell Oil Company's Denver, Colorado, area, has retired after a 37-year career with the company. He began work with Shell as a roustabout at Drumright, Oklahoma, in 1919. Penterman is a graduate of Carnegie Institute of Technology.

William D. Stuart has been appointed statistician for the Canadian Petroleum Association. He replaces **Ralph W. Diamond Jr.,** who left the association last month to take up an executive position with Triad Oil Company, Ltd. Diamond had been the CPA statistician for the past three and a half years. Upon receiving his degree of Bachelor of Commerce from the University of British Columbia, Stuart joined the land department of Imperial Oil, Ltd., in Calgary, Alberta, 1954, a position he has held until his new appointment.

Conger Reynolds, director of public relations for Standard Oil Company (Indiana) for 26 years, retired February 1 to become chief of the Office of Private Cooperation of the United States Information Agency in Washington, D. C. Reynolds will be succeeded by **Don Campbell,** now assistant director. **James M. Patterson,** an assistant director in the department, will become director of field service; **John Canning,** another assistant director, will be director of information services and **Robert Siebert,** copy chief, will be editorial director.

In 1948, Reynolds received the national award of the Public Relations Counsel of America, now the Public Relations Society of America, of which he is a director in the Chicago, Illinois, chapter. He was chairman of the national Oil Industry Information Committee in 1949 and received the honorary degree of doctor of laws and letters from Carthage College in 1952.

Jacques L. Zakin, senior research technologist with technical service department of Socony Mobil Oil Company, Inc., Brooklyn, New York, has been named the winner of Socony Mobil's 1956 Incentive Fellowship Award. Socony Mobil established the annual fellowships in 1947, and Zakin is the fifteenth to receive the award. He plans to work toward his doctorate degree in chemical engineering at New York University. Zakin attended Cornell University, where he received a BS in chemical engineering in 1949, and Columbia University, where he was awarded an MS degree in the same subject in 1950. He first joined the technical service department as a summer employee in 1949.

Almer F. Childers of the Cecil Hagen interests, Houston, Texas, has been made executive vice president of Toklin Oil Corporation. He was appointed a director of Toklan last June when it was acquired by Hagen. Before joining Hagen, Childers was a geologist with Gulf Oil for 23 years.

Paul E. Bermingham has been elected a director and appointed general counsel of General Petroleum Corporation. Bermingham joined General Petroleum in 1953 as associate general counsel. For ten years prior to that he was a member of the legal staff of Socony Mobil Oil Company in New York City.

Ralph O. Dietler has announced the opening of an office for oil and gas consulting, financing and investments in Tulsa, Oklahoma. He was formerly chairman of the board of Stanolind Oil Purchasing Company.

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DEATHS

Frank E. Rehm, retired vice president of Shell Oil Company, died November 27 at his home in San Francisco, California. He began his career in the petroleum business by working in the California oil fields during summer vacations while still an undergraduate at Stanford University. Since his retirement from Shell in 1953, Rehm had been secretary-treasurer of the Pacific Oil Institute.

Russell W. Bowers, 59, treasurer, manager of operations and a director of Sun Pipe Line Company, died at his home in Moylan, Pennsylvania, on January 7 after a heart attack. He joined Sun Oil Company in 1922 as an auditor after attending the Wharton School, University of Pennsylvania. He was appointed treasurer of Sun Pipe Line Company last November. Bowers also was treasurer of Sun Pipe Line Company of Michigan and Sun Pipe Line Company of Illinois and assistant treasurer of Sun-Canadian Pipe Line Company, Ltd.

Harold M. Davidson, 59, retired refining coordinator of Standard-Vacuum Oil Company, died November 16 in a Hospital, Morristown, New Jersey hospital, of a coronary thrombosis. He was one of the last three Stanvac executives to escape from the company's refinery at Palembang, Sumatra, before the Japanese occupation in 1942. Davidson, a chemical engineering graduate of Case Institute of Technology, entered the petroleum industry as an oil field worker in Louisiana and Arkansas. He had served as Stanvac's refining coordinator for ten years prior to his retirement last July.

Percy Norman Furber, 90, pioneer oil and film industrialist, died December 15 at his home in Darien, Connecticut. He is credited with being the first man to drill for oil in Mexico.

Dr. Laurence F. Athy, 57, who formerly was manager of Continental Oil Company's exploration department, died December 17 at Giddings, Texas, from a heart attack. He had retired from Conoco last year because of ill health. Dr. Athy joined the company as a geologist at Ponca City, Oklahoma, in 1925 and had been exploration manager since 1951.

Marshall L. Hough, 56, president of Darling Valve & Manufacturing Company, Williamsport, Pennsylvania, suffered a cerebral hemorrhage while at work on December 7 and died later that day in a Williamsport hospital. He had served as president and treasurer of Darling Valve for the past 20 years. Hough attended Cornell University Engineering School.

Joseph L. Comer, 61, vice president of the William Powell Company, died December 31 in New York City following a brief illness. Comer had been general manager of Powell's New York office since 1948.

Frank Edward Payne, 72, chairman of the board and co-founder of Crane Packing Company died November 20, at his home in Glencoe, Illinois, after a long illness. He began his career as a pump salesman. Payne served as president for 34 years until becoming board chairman in 1951.

Harold C. Miller, 66, regional director for the U. S. Bureau of Mines, Region 2, since 1949, died in Las Vegas, Nevada, December 18 after a heart attack. He had served with the bureau for 32 years, having joined it as a petroleum engineer. He made a number of notable contributions to petroleum technology, his best-known work being "The Function of Natural Gas in the Production of Oil," which led to widespread improvements in methods of conservation. Miller received an award of excellence from the Interior Department in 1943 and its highest award, the Distinguished Service Award, in 1953.

W. N. (Bill) Finnegan, Jr., who had been press relations chairman of Humble Oil & Refining Company, Houston, Texas, died of a heart attack late in December. He had worked for Humble since 1919 and retired a year ago.

Davis L. Wilson, 55, died January 5 in a hospital at Glendale, California, following a brief illness. Wilson for the past 14 years had served as secretary for George J. O'Brien, vice president of Standard Oil Company of California in Los Angeles.

Herbert G. Wylie, 88, pioneer oilman on the West Coast and former associate of the late Edward L. Doheny, died January 3 at his Los Angeles, California, home. A native of Dublin, Ireland, Wylie landed in this country at the age of 20 with a stake of $20. In 1902, he became an associate of Doheny and subsequently took charge of all of his Mexican oil holdings. He had been retired for the past 20 years.

W. R. "Frosty" Martin, 82, former president of the Long Beach, California, Board of Harbor Commissioners, died December 11. Martin, who resided in Long Beach, was known for his inventions of oil drilling equipment and was founder of the Martin-Decker Corporation of Long Beach. He retired from that firm in 1946.

William J. Murphy, 60, vice president in charge of sales and a director of American Potash & Chemical Corporation, died of a heart attack December 11 at a Glen Ridge, New Jersey, hospital. Murphy began his business career in 1911 in New York City with a predecessor company to American Potash & Chemical Corporation. He had been elected vice president in charge of sales in 1941 and to the company's board of directors in 1947.

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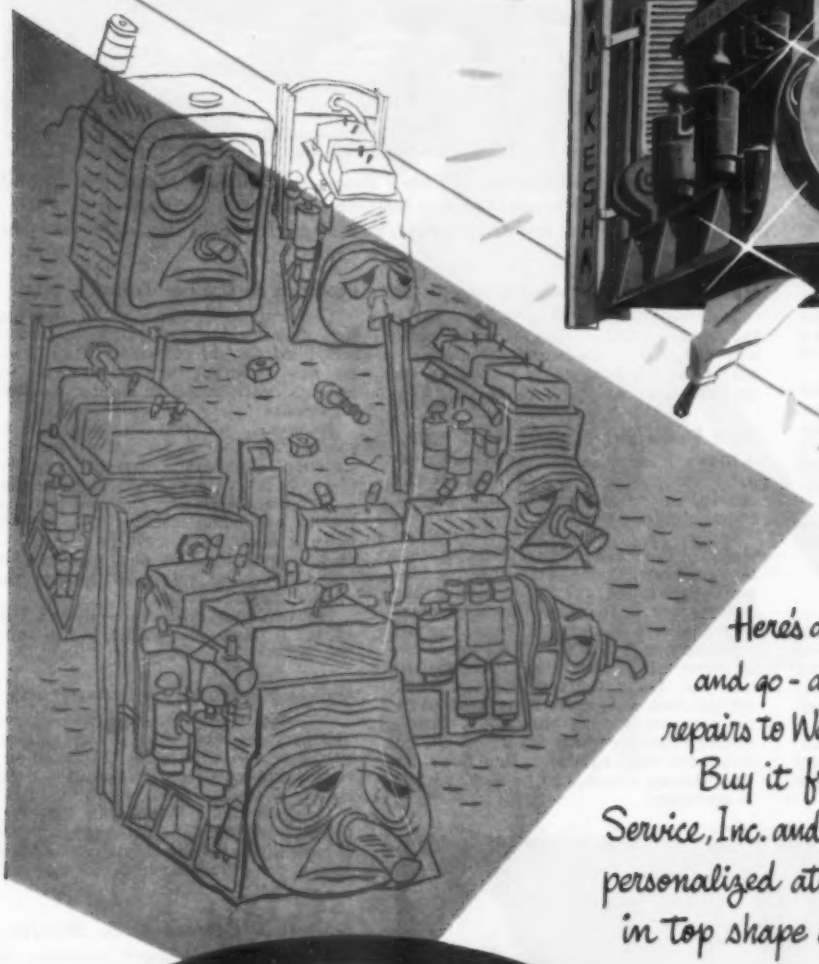

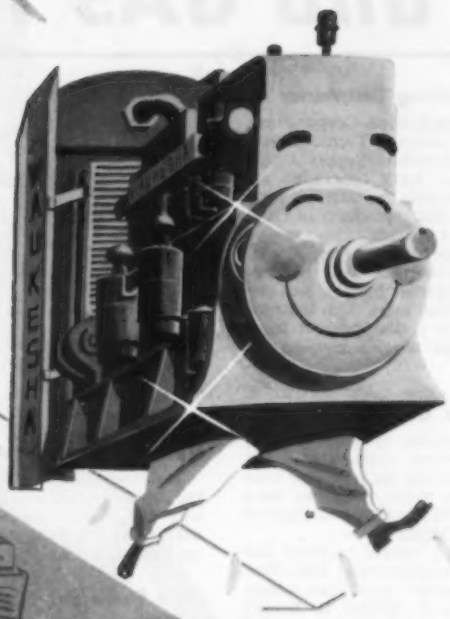

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OIL and GAS TRADE NEWS

Republic Is Roebling Distributor

John A. Roebling's Sons Corporation, wire rope manufacturers of Trenton, New Jersey, and The Republic Supply Company of California have concluded an agreement under which the latter is now distributor for Roebling products in California, Arizona and Nevada.

A full line of Roebling wire rope, slings, assemblies and accessories will be carried in stock by Republic Supply, particularly new Royal Blue extra high-strength wire rope, which is a development from Roebling 1105 rope wire, a high-carbon steel product.

New Telemeter Gaging System

A new telemetering system that can take tank gage readings, temperatures, and other data and transmit them on two lines to a central office miles away has been developed by the Pacific Coast division of Bendix Aviation Corporation.

Formerly, such a system required 204 lines and repeater stations every mile. This "Electro-Span System" uses lines rather than radio, which is utilized in Bendix radar and telemeter equipment for guided missiles and equipment for remotely guiding planes and PT boats.

One of the chief assets in using the Electro-Span System is its practical application in remote areas.

Microwave Facilities Expanded

Motorola's communications and electronics division has announced relocation of the division's microwave and industrial products department into new and expanded office, manufacturing and engineering quarters in Chicago, Illinois.

This phase of the company's activity, previously at the Chicago headquarters location, will now be centered in a modern one-story structure a few blocks away.

Recently completed plant of Cabot Shops, Inc., Pampa, Texas, has 43,000 sq ft additional floor space. The new building as well as other parts of the facilities are fitted with the latest equipment, including a hydraulic-bearing bone gear cutting machine.

New in Canadian Operations

Houston Oil Field Material Company, Inc., has opened operations in Canada with offices in Edmonton, Alberta, Canada. Hoyt N. Johnson is in charge of operations in that area.

New Trane Engineering Building

Bids will be taken by The Trane Company during early spring of 1956 for the construction of a 65,000 sq ft, L-shaped engineering building.

Main floor of the structure will include space for the company's product engineering department, design engineering department, several conference rooms, reception area, a microfilm room and blueprinting department. The mechanical equipment room will have a showroom appearance and feature a full glass wall so that the Trane CenTraVac (centrifugal refrigeration compressor manufactured by the company for big building air conditioning systems), which will supply chilled water for the engineering building's air conditioning system, can be viewed while in operation.

Foxboro to Double Training Site

The Foxboro Company is doubling the size of its training and education center. Scheduled for completion early in 1956, the new building will accommodate 46 trainees, nearly twice the number handled previously.

Plans call for two 20-student classrooms, two laboratories where bench instruction and service training can be given, an instrument demonstration room, a conference area, and enlarged quarters for the expanding teaching staff. Nearly twice as many courses will be offered, including specialized training in electronic instruments and advanced forums for various industry groups.

Norman A. Anderson and John B. Parkes Jr. have been added to the training staff.

Collins Purchases Subsidiary

Collins Radio Company has acquired 100 per cent ownership of Communication Accessories Company, an electronics component manufacturer, through an exchange of stock.

Communication Accessories Company specializes in the design, development and manufacture of toroids, audio band-pass filters, pulse transformers and magnetic amplifiers.

American Coldset Adds Division

The American Coldset Corporation has opened a new division in Denver, Colorado. This new operation known as Diamond Coring division, American Coldset Corporation, will encompass both diamond bit sales and coring services. Elmer Clutter of American Coldset's Hillmac division in the Permain Basin is being transferred to Denver to head the new branch. Bill Garms will be sales representative in the area.

Halliburton Adds to Buildings

Two major building expansions are being undertaken by Halliburton Oil Well Cementing Company at its Duncan, Oklahoma, headquarters.

Construction has started on a four-story addition for Halliburton's main office building at Plant One. The other major expansion is a new wing at the company's main technical center building, adjoining Halliburton Plant Two. Preliminary excavation work is already in progress on this. Both projects, to be completed within eight months, are part of Halliburton's current expansion program.

Tiny cobalt marble is placed in position with a 6-ft magnetic pole held by George Thomas Fisher, inspector for the Brewster Company. The cobalt capsule is powerful enough to penetrate the thick cast-steel walls of the big tri-plex hooks to expose radiographic film taped on the castings, thereby revealing any internal effects. By observing normal safety precautions, the inspector spends only 15 sec in actually handling the gamma rays.

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Niagara Alkali, Hooker Merge

Formal consolidation of Niagara Alkali Company into Hooker Electrochemical Company, both of Niagara Falls, New York, has been effected following a vote by stockholders of both companies in favor of the merger.

J. Clark Cassidy, formerly president of Niagara Alkali, has been elected a vice president and director of Hooker.

Niagara Alkali's facilities will be operated as the Niagara Alkal division of Hooker. The $12,000,000 assets of Niagara Alkali now raise Hooker's total assets to more than $100,000,000.

Rockwell Expands in Canada

Rockwell Manufacturing Company of Canada, Ltd., has begun production of Rockwell meter products in Canada for the first time at its Guelph, Ontario, plant and has opened a new sales office in Toronto.

Complete meter servicing facilities and warehouse space have also been added at the Guelph plant, where Thomas Wall has been named general manager. Sales of Rockwell's Delta power tools in Canada will also be handled through the Toronto office.

Huge Hydraulic Dynamometer

A 10,000-hp, 400-rpm capacity dynamometer, the West's largest hydraulic dynamometer, spun under load for the first time recently in San Francisco, California. It was built by Enterprise Engine & Machinery Company to test its new 12 and 16-cylinder RV-series diesel engines.

First test run for the new installation was with a Q-series tri-fuel engine rated 1755 hp at 360 rpm. This was one of four engines destined for service in New York City's expanded Bowery Bay sewage treatment plant. This dynamometer doubles test capacity at Enterprise and is low on upkeep.

The new "brake" weighs 90,000 lb.

Porter Division Has New Name

Watson-Stillman Fittings Division, H. K. Porter Company, Inc., has approved a change in its name to W-S Fittings Division.

The divisions trade mark, two diamonds separated by the letters, W-S, will be retained. The trade mark appears on all existing W-S fittings and will also be used to identify new products.

Consolidated Changes Name

Stockholders of Consolidated Engineering Corporation have voted a change in company name to Consolidated Electrodynamics Corporation.

Directors of the electronic instrument firm had approved the change earlier.

The new name was chosen because it describes better the operations of the company in the electronic instrument, data-processing, and high-vacuum fields.

Also Consolidated had been unable to qualify for intrastate business in certain key states under its previous name, which forced creation of a special subsidiary, CEC Instruments, Inc., to operate in such states. This unit is now being dissolved.

Consolidated Vacuum Corporation, the Rochester, New York, high-vacuum subsidiary of Consolidated Electrodynamics, has also been dissolved and its activities combined with those of the parent firm. It will be known as the Consolidated Vacuum division.

Treco Becomes Vitro Subsidiary

Vitro Corporation of America has contracted to acquire Refinery Engineering Company, which will become a wholly owned subsidiary of Vitro.

Treco, as it is known in the engineering business, will continue its operations on an expanded scale under its present management in Tulsa, Oklahoma.

The price to be paid by Vitro for Treco was not disclosed, but it is understood to be between $2,000,000 and $3,000,000 and that part of it will be in Vitro's common stock. Treco's annual construction contracts average in excess of $20,000,000 and Vitro's annual gross revenues are about $30,000,000.

New Corrosion Control Firm

A new firm Corrosion Control, Inc., Tulsa, Oklahoma, has been issued corporation papers from the state of Oklahoma. Officers are Claude L. Wright, president; Walter E. Shott Jr., vice president, and John E. Searcy Jr., vice president.

Aim of Corrosion Control will be to furnish corrosion control engineering services primarily analysis and treatments to the companies needing this service.

United Core, Inc., has moved into its home office building in Houston, Texas.

Stauffer, Consolidated Merging

In a joint statement, Stauffer Chemical Company and Consolidated Chemical Industries, Inc., has announced that agreement in principal had been reached on a plan of merger of Consolidated into Stauffer.

Total assets of the combined companies will be $120,000,000.

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Trade News

Benzonitrile for Commercial Use

Tennessee Products & Chemical Corporation has announced that developmental quantities of benzonitrile are available and now being produced at the company's Chattanooga, Tennessee, pilot plant under a new process developed at the company's research laboratories.

Benzonitrile, latest addition to TP&CC's fast-growing product list of organic chemicals, is adaptable for use by a wide range of chemical process and other industries, including plastics, rubber, organic synthesis, pharmaceutical, textile, leather, synthetic coatings and solvents.

Developmental quantities of benzonitrile now being produced will be allocated to interested industries for experimental purposes.

Pipe Supply Company in Canada

Formation of the Prairie Pipe Company, Ltd., of Regina, Saskatchewan, to manufacture steel pipe for the oil and gas industries has been announced.

Operating as an affiliate of the Fluor Corporation, the new company's plant will be located on a 110-acre site, already purchased, on the outskirts of Regina.

Fluor Corporation of Canada will construct the plant, and Cal-Metal Corporation, Torrance, California, has been awarded a contract to furnish all the machinery and equipment for the plant.

President of the new company is D. W. Darnelel, Fluor Board chairman. J. E. Cunningham, former district engineer for Fluor in Houston, has been named vice president and general manager.

New Supply Ship in Service

The "M. V. Tioga," first of two twin-screw 131-ft. supply vessels built for The California Company for service offshore, has been delivered by Equitable Equipment Company.

This ship has gone into service deliver-

ing drill stem, casing, mud, cement, fuel oil and fresh water to the many fixed and portable drilling platforms operated by The California Company in the Gulf of Mexico.

The "Tioga" was designed to operate from a shallow-water base, to have utmost maneuverability, to operate in the open sea far off-shore, to carry the maximum deck load, to have quarters for a crew of 8 men and 40 passengers and to have efficient towing characteristics. All crew quarters, passenger space, and pilot house are air-conditioned.

Shand and Jurs Acquired by GPE

An agreement has been reached for the acquisition by General Precision Equipment Corporation of the majority of the outstanding stock of Shand and Jurs Company, Berkeley, California.

Pioneer in the development of equipment related to the safe storage and transportation of volatile liquids, Shand and Jurs was organized originally in 1922. Sales of the company for the year 1955 are estimated at $2,500,000.

Under terms of the acquisition agreement, 10,317 shares of GPE $4.75 cumulative preferred stock and 21,000 shares of GPE common stock will be issued in exchange for all outstanding stock of Shand and Jurs except for 20 per cent of a junior preferred, which will be exchangeable over a period of years for GPE common stock. Upon consummation of the acquisition, expected early in January, Shand and Jurs will join the GPE group of operating companies but will continue to be operated as a separate corporation under the present management.

Atlas Merger Nears Completion

Directors of Atlas Corporation, RKO Pictures Inc., Airfleets, Inc., San Diego Corporation and Wasatch Corporation have approved a proposal for the merger of their respective companies, with Atlas continuing as the surviving company.

Directors of Albuquerque Associated Oil Company, also included in the merger plan, have approved the proposal in principal and are expected to take formal action soon.

Combined assets of the merged company will total approximately $110,000,000 based on November 30, 1955, pro forma figures. The proposed merger will require a two-thirds vote of the shareholders of the respective companies.

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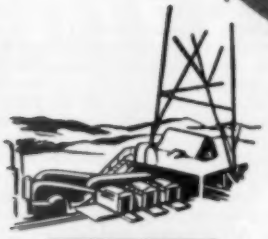

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TRADE PERSONALS

G. E. Kopetz

A. O. Olson

George E. Kopetz has been elected to the position of vice president in charge of production of Blaw-Knox Company. At the same time, the promotion of four veteran employees to newly created posts of vice presidents in the company's chemical plants division has been disclosed. **Arne O. Olson** was named vice president in charge of engineering; **Keator McCubbin,** vice president and manager of chemical plants division's Midwest headquarters, Chicago, Illinois; **Charles F. Hauck,** vice president for sales, and **Edward S. Wright,** vice president in charge of construction.

Kopetz joined Bawl-Knox in 1939, following many years of experience as an engineer in the chemical industry, and had been vice president and assistant general manager. Associated with Blaw-Knox since his graduation from Carnegie Institute of Technology in 1930, Olson has won distinction as an authority on many chemical processes, particularly in the field on synthetic resins.

Theodore C. Beug has been named advertising manager for both the industrial and precision divisions of Foote Brothers Gear and Machine Corporation. He has served as an advertising manager and sales promotion manager in the heavy construction equipment industry after attending the Chicago Academy of Fine Arts. **Richard H. Ewert** has been appointed to the newly created position of manager—gearing sales at Foote Brothers. Ewert, a veteran in the gear industry for a number of years, is a graduate of Massachusetts Institute of Technology in mechanical engineering and also attended Illinois College.

Ralph W. Barnes has been appointed customer liaison manager of the eastern division of the Servomechanisms, Inc., Westbury, New York. Prior to his appointment, Barnes was contract manager of the Electronics Corporation of America. Barnes received his BA in physics and mathematics from Ohio Weslevan University and an MA in physics from Columbia University. He also completed post graduate courses at Duke and Columbia Universities.

Fairest Brown has been appointed assistant division manager of the Rocky Mountain division of Welex Jet Services, Inc. Brown, who will headquarter in Denver, Colorado, where Welex is opening its new division office, is a veteran of four years with the company.

Harris Sisson has been appointed vice president and sales manager for the Empire Machinery Company. For the past ten years, Sisson has been active in all phases of the company and has had wide experience in the service and supply business in the Permian Basin. **C. E. Bills** has been appointed vice president and assistant general manager of all operations for the Empire. Previous to this Bills was on the executive staff of the Parkersburg Rig and Reel Company as manager of systems planning.

Robert F. Schulz has been made manager of Motorola's new department, the microwave and industrial products department. Commercial sales activities will be directed by **Leonard G. Walker** and **James Stewart** will be in charge of export and special accounts sales. Since joining Motorola in 1953, Schulz has directed the engineering, production and sale of the Motorola line of microwave equipment. Prior to his new assignment, Walker was product manager for power utility products.

R. F. Schulz

Robert W. Fisher, sales manager for Frank Wheatley Pump and Valve Manufacturer since 1952, has been appointed vice president and general manager. **Orbie L. Sumner** has been named assistant general manager and **Jack E. Metzger** secretary-treasurer. Sumner was formerly pilot and service manager.

N. V. Chehak

J. W. Rockwell

N. V. (Norb) Chehak has been appointed assistant sales manager of Link-Belt Speeder Corporation. Chehak, a University of Wyoming graduate, has been with Link-Belt Speeder since 1949, first in the company's sales office and for the past four years as the firm's district representative in the Pacific Northwest and Canada.

J. W. Rockwell has been appointed sales manager, hydraulic unit division, for the Axelson Manufacturing Company, division of U. S. Industries, Inc. Rockwell has for the past 18 years been with his company in the Mid-Continent oil fields but will now be headquartered in Los Angeles, California. He is a graduate of Northwestern University.

L. R. Hill

W. H. Barnes

Luther R. Hill, petroleum and chemical engineer and formerly president of Process Designs, Inc., has joined Arthur G. McKee & Company as process coordinator of the petroleum division. Hill was graduated from the University of Texas with a BS in chemical engineering. He started his business career as a chemical engineer in the plant control laboratory of the Texas Pacific Coal & Oil Company in Fort Worth, Texas.

William H. Barnes has been elected vice president and general sales manager of the C. Lee Cook Company. Before joining Cook, Barnes had been associated for ten years with Clark Brothers Company in Tulsa, Oklahoma, the past two and a half years as district manager.

Mathew L. Freeman has been appointed controls division engineer for McEvoy Company. Freeman comes to McEvoy from nine years with the Atlantic Refining Company, where he was engaged as laboratory design engineer, designing and fabricating all types of electrical and pneumatic controls.

Jack H. Walters, gas products manager for the past year, has been named manager of gasoline and oil products for Rockwell Manufacturing Company's meter and valve division. **Robert B. Kitzmiller,** San Fancisco, California, district sales manager since 1952, has been named gas products manager. **T. O. Carson,** assistant product manager, Nordstrøm valves, has assumed the additional responsibility of manager of distributor sales. **N. F. Groom,** a sales engineer from the Houston, Texas, district, has been named assistant manager of distributor sales. All four will make their headquarters in Pittsburgh, Pennsylvania.

Don L. Louvier has joined Rockwell as sales engineer at Farmington, New Mexico. A graduate of the University of Tulsa, Louvier has spent four years in sales and service work with the Murlin Company.

Frank L. Rubin, who is widely known for his papers in the field of heat transfer design, is now a member of the sales engineering staff of Downingtown Iron Works, Inc. Rubin has had 15 years experience with the chemical, petrochemical, petroleum and power industries. During the past three years, he has served as senior job engineer, with special emphasis on heat transfer problems, on AEC projects, chemical plants and refineries.

Joseph E. Maurey has been elected president of the Multiple V-Belt Drive & Mechanical Power Transmission Association, Chicago, Illinois. **H. Merrill Bowman** has been named vice president. Maurey is vice president and general manager of Maurey Manufacturing Corporation, Chicago, while Bowman is vice president of The American Pulley Company.

F. G. Taves

M. E. Loy

C. K. Ruddick

C. A. Doh

Fritz G. Taves, former Pacific Coast area manager and recently on the staff of the president of the Schlumberger Well Surveying Corporation, has returned to his former post with headquarters in Los Angeles, California. **Milton E. Loy,** former Pacific Coast area manager, has been named Mid-Continent area manager in Tulsa, Oklahoma. **Charles K. Ruddick,** former Mid-Continent manager, has moved to New Orleans, Louisiana, as manager of the Southwest area. **Charles A. Doh,** former Southeast manager at New Orleans, has been transferred to Houston to take on the newly created position of manager of customer relations.

Taves received a BS in petroleum engineering from the University of California in 1922 and joined Schlumberger in 1935. Loy began work with Schlumberger in 1940 after graduating from the University of California in 1938. Ruddick was graduated from the University of Illinois in 1934 and received his masters' degree in electrical engineering from MIT in 1935. Doh is a graduate of the University of Arts and Crafts in Paris, France.

A. K. Babel has been promoted to division sales manager of northern South America for Hughes Tool Company, with headquarters in Maracaibo, Venezuela. Having been with the company since 1940, Babel has represented the company in various sales capacities in the Mid-Continent fields of the United States and since 1948 has had extensive experience in South America. **L. H. Brothers** has been promoted to special representative in Venezuela, to be located at Anaco. At the time of his transfer, Brothers was district sales manager at Corpus Christi, Texas. **J. R. Forbes** has been advanced to district sales manager in Corpus Christi. Prior to his promotion, Forbes was in San Antonio.

Paul Azzolina has been named manager of the service department for the Le Roi Division, Westinghouse Air Brake Company. He was formerly assistant manager of the service department.

Robert E. Hunter has been made general sales manager of the Detroit Diesel Engine division of General Motors, having been until this appointment director of sales of General Motors Diesel, Ltd., of Canada. Hunter, an engineering graduate of the University of Michigan, first joined General Motors in 1937 as business management manager at the Pontiac Motor division. Hunter replaces **E. F. Bentley,** who is going on special leave of absence.

R. E. Hunter

M. Maddox

Mel Maddox has been named sales manager of Pipelife Corporation, having been in the pipe line industry for over ten years in sales and service of protective coatings, pipe line supplies and equipment. He was previously district manager of Pittsburgh Coke and Chemical in Atlanta, Georgia.

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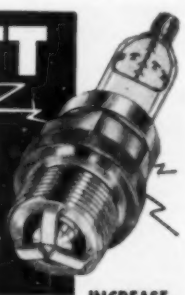

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Trade Personals

Robert Hume has been promoted from southern district sales manager to export and Houston, Texas, area sales manager for the Weatherford Oil Tool Company. Succeeding Hume as district sales manager is **Homer A. Longino,** assistant southern district sales manager. Hume has been with Weatherford for six years, and Longino has been employed by the company since 1954.

Jack R. Bechtold has been named to head mast and drilling structural sales for Emsco Manufacturing Company. A graduate of Oklahoma A. & M., Bechtold for the past six and a half years has been working in design and sales with the Lee C. Moore Corporation of Tulsa, Oklahoma.

Harold P. Gustavson has been made petroleum equipment sales manager of Electro-Motive Division of General Motors, with headquarters in Tulsa, Oklahoma. Gustavson, a mechanical engineering graduate of Illinois Institute of Technology, has been in locomotive sales as a district sales manager of the firm's New York City region. **Arthur M. Hazell, Jr.,** has been named sales representative for petroleum equipment with offices in Houston, Texas, and **R. H. Beight** has been appointed technical engineer, with headquarters in Fort Worth, Texas. Hazell had been a sales representative, New York region, since 1952.

B. C. Robertson, Don Weekes and **R. R. Hirsch** have all received promotions with Lone Star Steel Company. Robertson, formerly Houston, Texas, district manager has been named manager, oil country goods sales. Weekes has been appointed manager line pipe sales while Hirsch has been made manager, order scheduling department. Both Weekes and Hirsch were formerly assigned to the general sales staff. Succeeding Robertson in the Houston office is **Tom Pearson,** who was previously employed by Ada Oil Company.

David G. Willis has been appointed publications and publicity assistant of Magnet Cove Barium Corporation. In this capacity he will assist in the editing of the company's internal publication, *Magco Scene,* and the preparation of its publicity material.

Willis was formerly associated with Goodwin-Dannenbaum Advertising, Houston, as both account executive and publicity director. Previously he was a member of the editorial staff of *Petroleum Refiner* magazine, published by Gulf Publishing Company. A native Houstonian, he was graduated from the University of Houston with a BA degree in English in 1952.

Bill J. Ellis has been named caliper engineer for Otis Pressure Control, Inc., in its New Iberia, Louisiana, division. Ellis formerly was in the firm's Longview, Texas, division office and also has been stationed at Otis' branches in Houston and Victoria, Texas. A graduate of Texas A & M College with a degree in petroleum engineering, Ellis began with Otis in 1950. He formerly worked for Gulf Oil Corporation in Odessa.

George L. Bond and **E. S. Rothrock** have been elected directors and vice presidents of the Stauffer Chemical Company. Bond was formerly president and Rothrock, executive vice president of Consolidated Chemical Industries, Inc., which merged with Stauffer last November. Rothrock has been appointed general manager of Stauffer's Consolidated Chemical Industries Division.

Dr. Harold V. Gaskill of Iowa State College has accepted a position as vice president in charge of planning with Collins Radio Company. As dean of the division of science and director of the Industrial Science Research Institute at Iowa State College since 1938, Dr. Gaskill has been in charge of the research planning of the institute. He has planned and directed research in positions with the government and army during World War II, the Korean emergency, and on the Manhattan Project.

Henry Gusman, Continental Copper & Steel Industries, Inc., vice president, who has headed the Wooldridge Manufacturing Division organization in Sunnyvale, California, since its founding in 1937, has moved to New York City as a member of the CCS management committee. **J. D. Gusman,** formerly assistant to the general manager of Wooldridge Division, has been named as general manager of Wooldridge and assistant vice president of CCS. **E. E. Esgate,** formerly a vice president of Thew Shovel Company, is now general sales manager for Wooldridge.

Don W. Lyon has been elevated to general sales manager of the textile division of L.O.F. Glass Fibers Company, succeeding **C. F. Hegg,** who recently was named to head a new automotive sales division. Previously, Lyon had been manager of textile sales for L.O.F. Glass Fibers and earlier had held the same position with the Fiber Glass Division of Libbey-Owens-Ford Glass Company before the latter division merged with Glass Fibers, Inc., to form the new company. He received a BS in architecture from the University of Michigan.

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Frederick S. Rich, formerly senior instrument engineer for Arabian American Oil Company, has been appointed petroleum industry coordinator for Fischer & Porter Company. Rich, who has had 22 years experience in instrumentation, 20 of which have been in the petroleum industry, attended Wentworth Institute and Massachusetts Institute of Technology.

Don B. Sandford has been appointed manufacturer sales representative, industrial power division, International Harvester Company, with headquarters in Dallas, Texas. A 21-year employee of International Harvester Sandford has spent his entire service with the company in engineering design and sales engineering.

Ed Von Rosenberg has been appointed chief metallurgist of American Iron and Machine Works Company, Inc. Rosenberg, a mechanical engineering graduate of Texas A. & M. College, was formerly a metallurgist senior with Reed Roller Bit Company. **Harry Falter, Jr.,** has been named advertising manager. Falter began work with American Iron in 1947 as product engineer on tool joints, and in 1950 he was transferred to the advertising department as assistant advertising manager and served in this capacity until his recent appointment. **J. M. Taylor** has been made export manager for the company with his headquarters in New York City. Taylor has had 20 years experience with American Iron.

Bryan O. Bishop, technical representative, is in charge of Perforating Guns Atlas Corporation's new Fort Worth, Texas, branch office. Bishop received his degree as petroleum engineer from the University of Oklahoma and had been assigned to PGAC's West Texas division until his recent promotion. **Philip Stoore, Jr.,** technical representative, is in charge of the new branch office at Tulsa, Oklahoma. He served for three years as district radioactivity engineer with PGAC's five Oklahoma branches until his recent promotion. **Paul Felder,** sales representative at the company's Lake Charles, Louisiana, office, has been transferred to the Shreveport, Louisiana, office to serve in the same capacity. Felder holds a BS in petroleum geology from Mississippi State College. **Charles Melvin,** PGAC sales representative for the past year at Liberal, Kansas, was recently transferred to the company's station at Great Bend, Kansas, to serve in the same capacity.

Edmund M. Wise has been appointed assistant to the vice president-manager of the development and research division of The International Nickel Company, Inc. Wise, a graduate in metallurgy from the University of Wisconsin in 1919, joined Inco in 1927 to take charge of platinum metals research at the research laboratory at Bayonne, New Jersey. Since 1933, Wise has been in the New York City office.

Dr. George T. Paul has joined International Nickel as a member of the development and research division's corrosion engineering section in New York. Dr. Paul holds the degrees of Doctor of Philosophy, earned in the department of chemical engineering, and Master of Arts (in chemistry) from Columbia University and a Bachelor of Arts degree from Columbia College. Before joining International Nickel, Dr. Paul was with the American Cyanamid Company.

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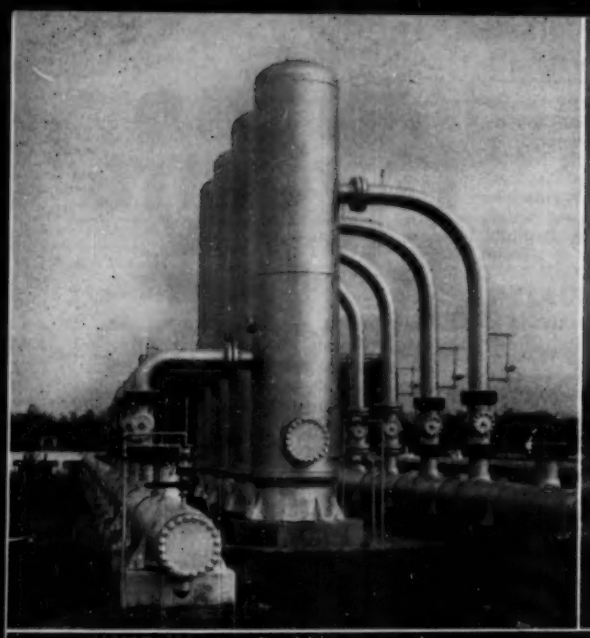
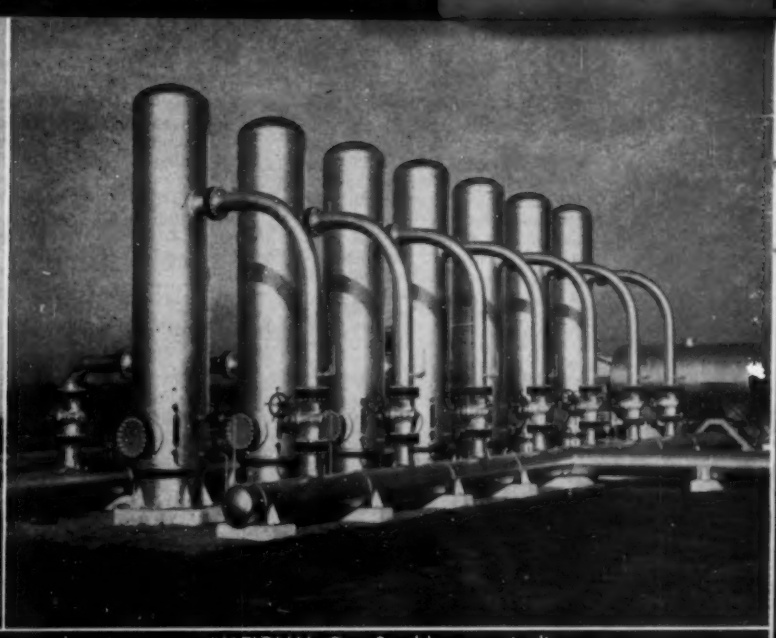
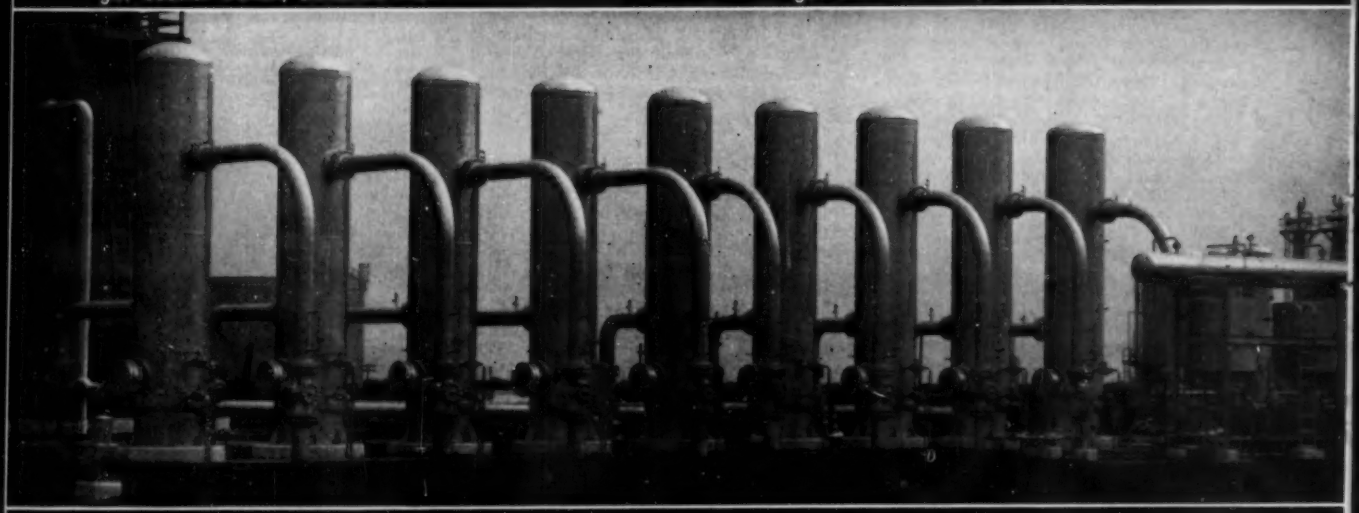


NATIONAL Gas Scrubbers, main line gas booster station, Batesville Miss.



NATIONAL Gas Scrubbers, main line gas booster station, Monroe, La.



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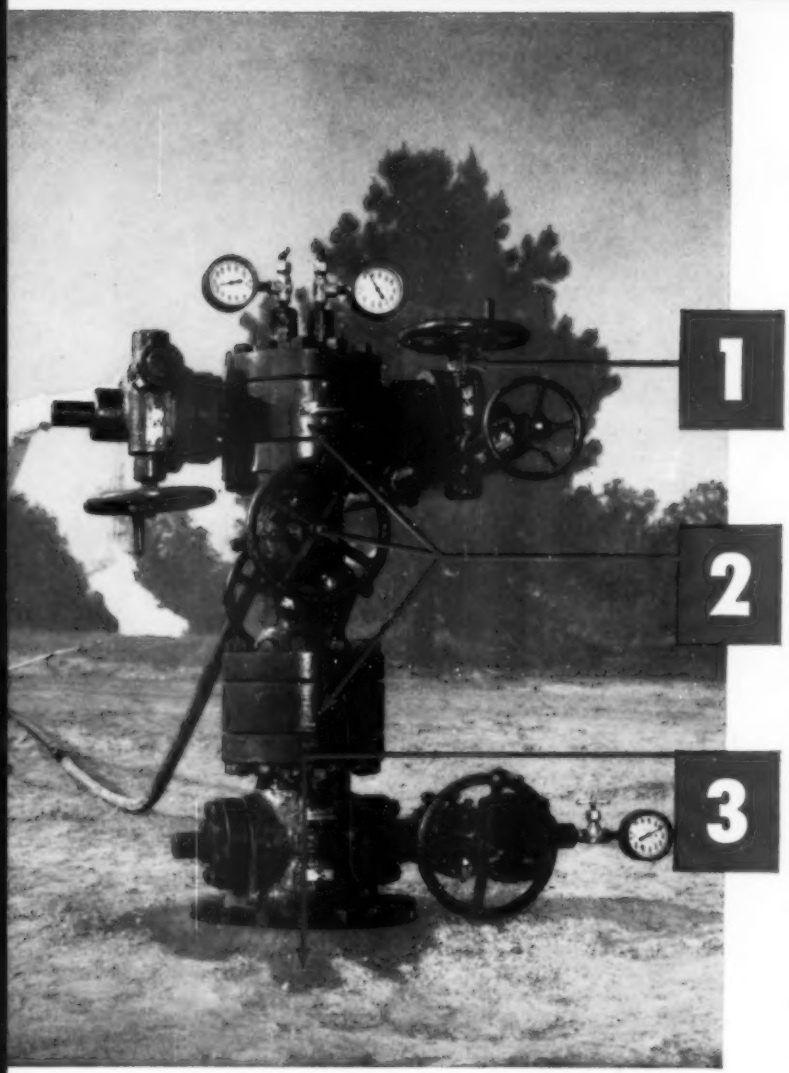

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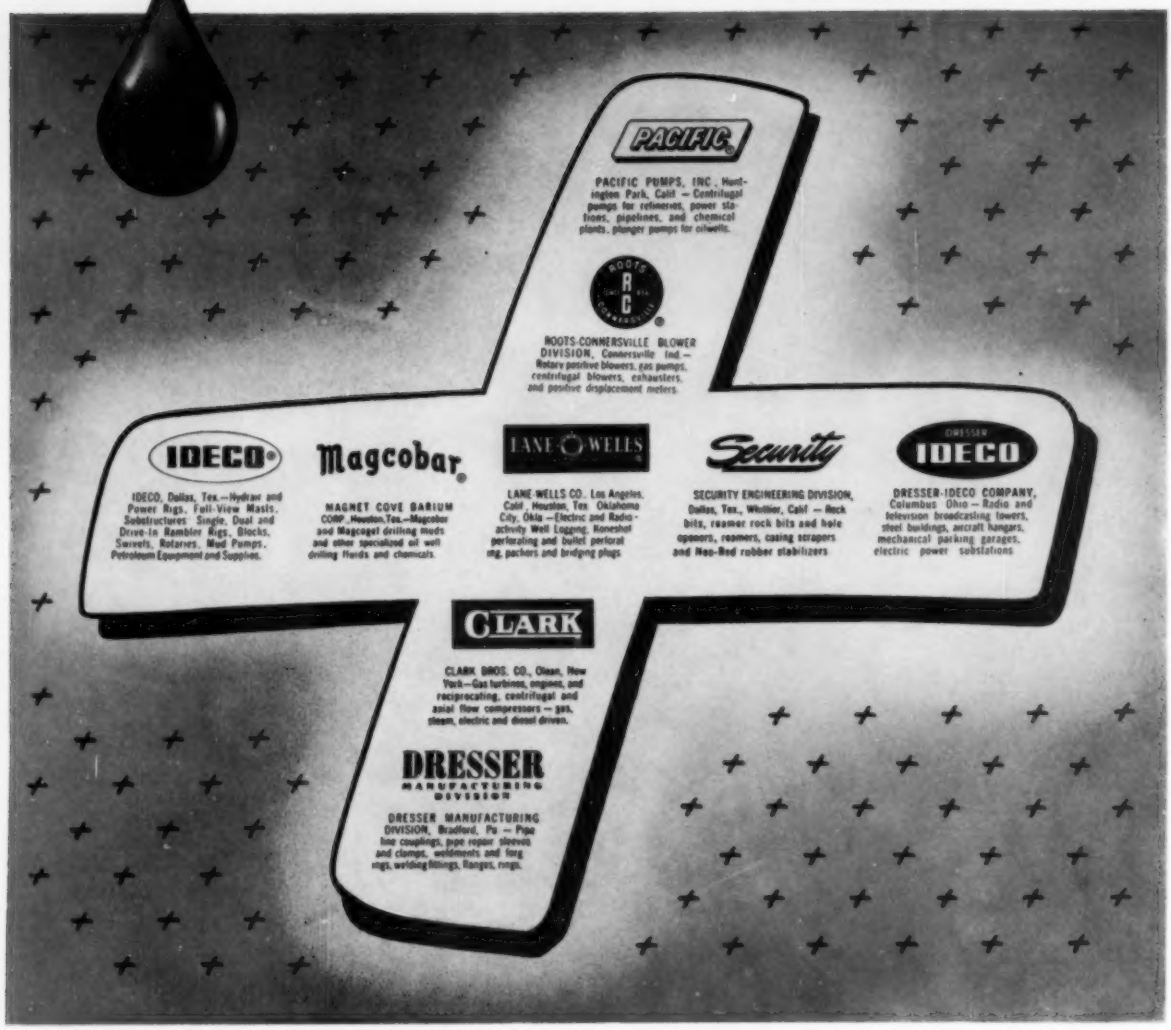
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Of Things To Come . . . In OIL

TEXAS OIL AND GAS PRORATION may be due for major shakeup this year. RR Commission is beginning spot-checks in several shutdown-exempt fields to determine pressure effects under normal regulation. Proponents hold that special allowable situations are "out of hand". Louisiana's ratable take of gas is getting close scrutiny by Texas eyes for possible inclusion into RRC conservation rules.

FOREIGN OPERATIONS will be written into 1956 budgets of many smaller independents and drilling contractors. Foreign trade organizations and government agencies are coaxing "the little man" with lucrative exploration and drilling concessions. Tax considerations are appealing, and many point out that in U.S. only 13 bbl of oil reserves came from each foot of hole drilled. In Canada, return was 27 bbl and in Venezuela, 260 bbl.

STATE OFFSHORE BOUNDARIES may be established soon, once and for all. Suit will be brought against Louisiana in the near future to challenge its right to a 10½-mile limit, state attorney general Fred LeBlanc has been advised. U.S. claims it has never recognized boundaries more than three miles offshore by any state or nation.

DEPLETION ALLOWANCE SAFE THIS YEAR, although not without many attacks, especially during debate on gas bill and tax legislation. Joint Congressional Committee studying tax changes has scrutinized depletion allowance without retention or suggesting immediate changes.

DEEP DRILLING OFFSHORE is in the offing as soon as technological developments bring costs within reason. Sedimentary source beds exist down to 30,000 ft and below, and pay sections totalling 1000 ft have been encountered already. Many known potential structures are yet to be explored by the bit, especially the deeper and generally more prolific horizons.

LABOR UNION ACTIVITY TO INCREASE IN 1956 throughout most branches of the oil industry based on increased strength of CIO-AFL merger. Large membership budgets are available. Targets are big, new petrochemical plants, service stations, and a renewed drive on field personnel.

ALASKA OIL FEVER is gaining momentum, with one major operator already moving tools into far north country. Impetus may be credited to solving subzero operating problems, and likelihood of additional federal leasing of some 20-28,000 acres and approval of $25 million Alaska pipe line.

CHEAPER DRILLING NEEDED now worse than ever, and it's going to be a knotty problem to achieve. Improved technology and tax considerations are two promising avenues. More wells must be drilled if U. S. is to maintain healthy ratio of reserves to production in face of accelerating demand and lower discovery ratios.

WHEREVER YOU'RE LOCATED

there's a Bucyrus-Erie spudder distributor nearby

Here's an up-to-date list of Bucyrus-Erie spudder distributors, located throughout the United States and Canada, who are ready to fill your equipment needs. Check for the name of the distributor nearest you. Then see him soon for details on how Bucyrus-Erie spudders can save you money on your drilling and well servicing jobs.

SALES Your Bucyrus-Erie distributor carries the world's most modern and complete spudder line. Four models: 60-L, 28-L, 36-L, 48-L; maximum drilling depth, 6000 ft.; servicing, 7000 ft.

SERVICE Chances are your Bucyrus-Erie distributor began years ago in the drilling business himself. He knows drilling procedures inside and out. Extensive personal experience qualifies him to recommend tools and equipment to you.

PARTS Whenever and wherever you need tools or parts service, you needn't look far for help. There are 38 distributor outlets for Bucyrus-Erie spudders located in all principal oil fields of America. Each distributor has the facilities and parts inventories to keep your rig in top running condition.

Write, Wire or Phone

BEACON SUPPLY CO. . . . Pampa and Borger, Tex.

BECKWITH MACHINERY CO. . Pittsburgh (East Liberty), Erie, Bradford and Clearfield, Pa.

BUCKEYE SUPPLY CO. . . . Zanesville and Wooster, Ohio; Wichita, Chase, Arkansas City and El Dorado, Kan.

CABLE TOOL SUPPLY CO. . . Princeton, Ind.

DRILLERS SUPPLY CO. . . . Joplin, Mo.

DRILLING AND MINING EQUIPMENT CO. . . . . . Los Angeles, Calif.

GREAT NORTHERN TOOL & SUPPLY CO. . . . . . Billings, Cut Bank and Kevin, Mont.; Casper, Wyo.

IVERSON SUPPLY CO. . . . Tulsa, Oklahoma City and Okmulgee, Okla.; Ft. Worth., Midland, Odessa and Snyder, Tex.; Artesia and Farmington, N.M.

McJUNKIN CORPORATION . Charleston and Hamlin, W. Va.; Allen and Pikeville, Ky.

OLYMPIC SUPPLY CO. . . . Seattle, Wash.

THE STRAKER SUPPLY . . . Mt. Pleasant, Mich.

CANADA

LUCEY CANADIAN SUPPLY CO. Calgary and Edmonton, Alba.

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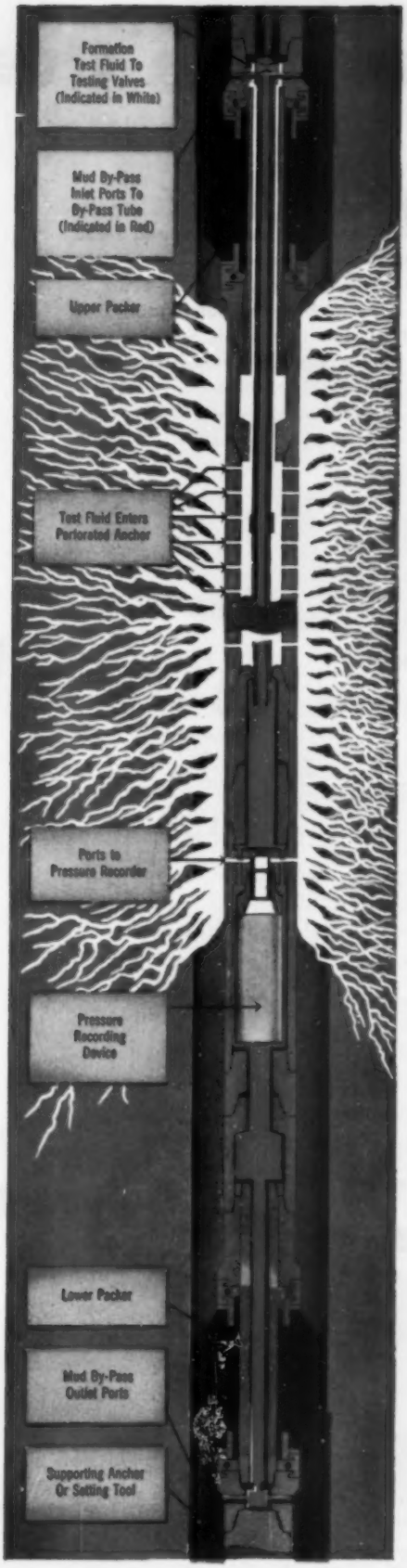
Formation Test Fluid To Testing Valves (Indicated in White)
Mud By-Pass Inlet Ports To By-Pass Tube (Indicated in Red)
Upper Packer
Test Fluid Enters Perforated Anchor
Ports to Pressure Recorder
Pressure Recording Device
Lower Packer
Mud By-Pass Outlet Ports
Supporting Anchor Or Setting Tool

Straddle Testing

in open hole

another Johnston first*

Now, with complete confidence, you can...

- **EVALUATE UP-THE-HOLE ZONES**
- **LOCATE GAS, OIL, AND WATER CONTACT**
- **HELP PROTECT HOLE AND SUPPORTING ANCHOR**

See how Johnston Straddle Testing with STRADDLE MUD BY-PASS maintains full hydrostatic mud pressure on upper and lower packers—and on all formations below lower packer. Lessens the load on supporting anchor and prevents production from any lower zone in the event of lower packer failure. Should either packer fail, you get an immediate surface indication. Get all these advantages plus ease of running tool into and out of the hole.

*Johnston Straddle Testing with Straddle Mud By-Pass is covered by patent and patents pending. Another Johnston first!

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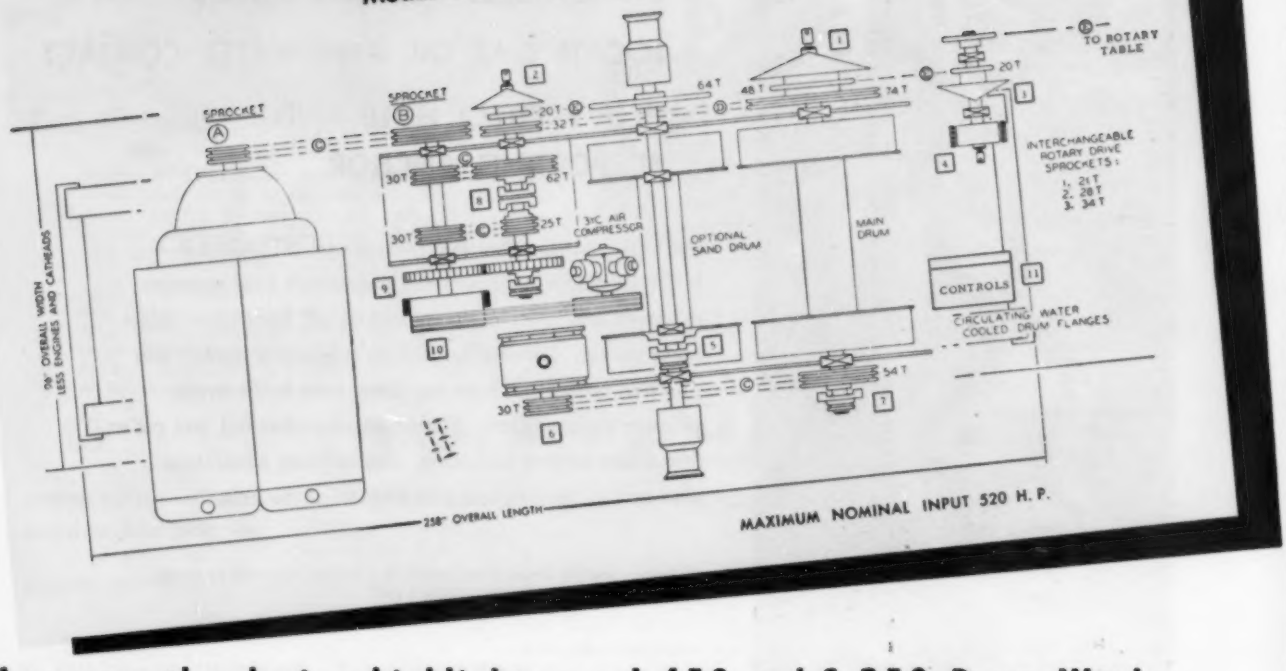
FORMATION AND CASING TESTING
JOHNSTON

"These are the

We are proud of field performance reports received from owners of our S-350 and J-450 draw works currently operating in Illinois, Kansas, and Bolivia. Now, after 30 years of experience building the most outstanding and longest-lasting rigs in the oil industry, we present to you these two unexcelled draw works that offer the best combination of construction features ever devised for operator convenience and low maintenance.

A. W. Caldwell

Model S-350 Power Flow Diagram



Here are the design highlights . . . J-450 and S-350 Draw Works

1. Air Friction Clutch Drive for Main Drum.
2. Air Friction Clutch Drive to Cathead Shaft.
3. Air Friction Clutch—Rotary Drive.
4. Rotary Table Brake.
5. Sand Line Drum, Air-Controlled Jaw Clutch.
6. Optional 22" Hydromatic Brake.
7. Automatic Release Jaw Clutch on Hydromatic Brake Drive.
8. Two-Speed Transmission, Air-Controlled Jaw Clutch.
9. Optional Constant Mesh Reverse Gear with Air-Controlled Jaw Clutch.
10. Air-Controlled Inertia Brake for Transmission Shifting.
*11. Fawick P. T. O. Clutches for Alignment and Removal of Engines.
*12. Optional Pump Drive—Air Friction Clutch.

*J-450 Only.

Finest DRAW WORKS

we've ever built!"

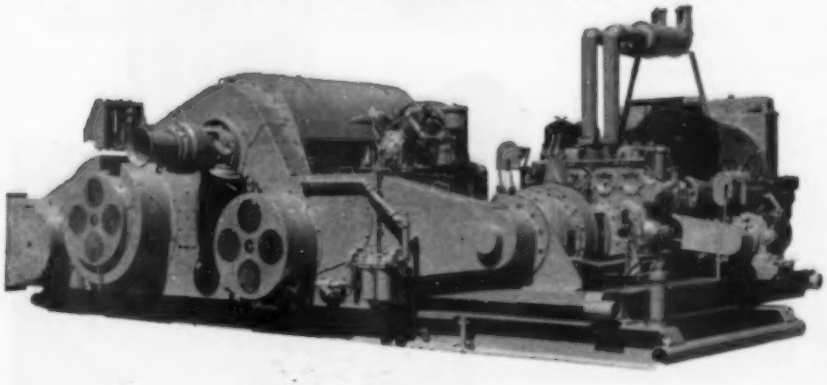
Model J-450
Twin-Engine Draw Works

Here, Cardwell engineers present a completely integrated design, which takes full advantage of high-strength alloys to provide a rig of light weight, while retaining ample safety factors for its nominal rating.

These sound basic designs can be readily expanded as your future requirements develop. This machinery has a pleasing symmetrical appearance, yet is strictly functional in its concept. The equipment is easy to keep clean, yet every working part is readily accessible from the outside.

This flexible unit was designed with convenience and low maintenance in mind.

Model S-350 Single-Engine Draw Works



The Model S-350 single engine torque converter draw works combines the latest in design features. It can serve as a compact, powerful split rig if desired.

The hoist portion of the Model S-350 is identical with that in the Model J-450, and will receive the same accessories.

CARDWELL MANUFACTURING COMPANY, INC., WICHITA, KANSAS, U. S. A.

CARDWELL

REG. U. S. TRADEMARK PATENT OFFICE

"This time I'm running a **MARTIN"**

MARTIN PLUNGERS & CAGES

Martin Plungers are especially good where sand or salt water conditions occur. Water is a lubricant for rubber. And since the Martin Plunger uses numerous split rubber-and-duck rings, the water content of the well actually serves as an efficient lubricant for the Martin Plunger. In sand, Martin Rings form a sand resistant seal without a tight, wearing fit in the working barrel . . . won't score or scratch.

Martin Cages often double ball and seat life. The resilience, resistance to sand abrasion, non-magnetic character and electrical resistance of the rubber guide cause the Martin Cage to perform better and longer than ordinary cages.

There is a Martin Plunger and Cage for your particular installation and conditions. Write for John Martin Catalog No. 4, which gives complete details.

Martin Plungers and Cages are available through all supply stores.

JOHN N. MARTIN

Manufacturer

9 W. BRADY • TULSA, OKLA.

WHY J&L RECOMMENDS ideco SWIVELS

IDECO swivels have a floating, self-centering wash pipe.

Contractors tell us they commonly drill four or five wells, with pressures from one thousand to two thousand pounds, before replacing washpipe or packing in an IDECO.

When finally needed, the special packing cartridge can be installed by one man in a few minutes—usually with no more than 20 to 25 minutes of downtime.

These IDECO Streamlined Swivels are made in four sizes for light, medium, and heavy drilling.

You can have them with either tapered or straight roller main bearings—the assemblies are interchangeable.

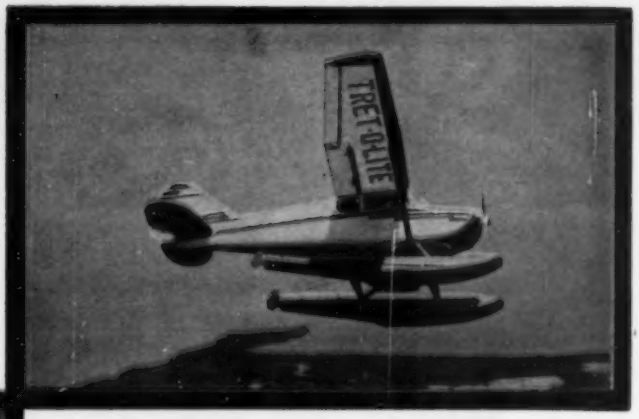
All J&L men can supply an IDECO bulletin on these remarkable streamlined swivels. Ask for your copy.

Jones & Laughlin

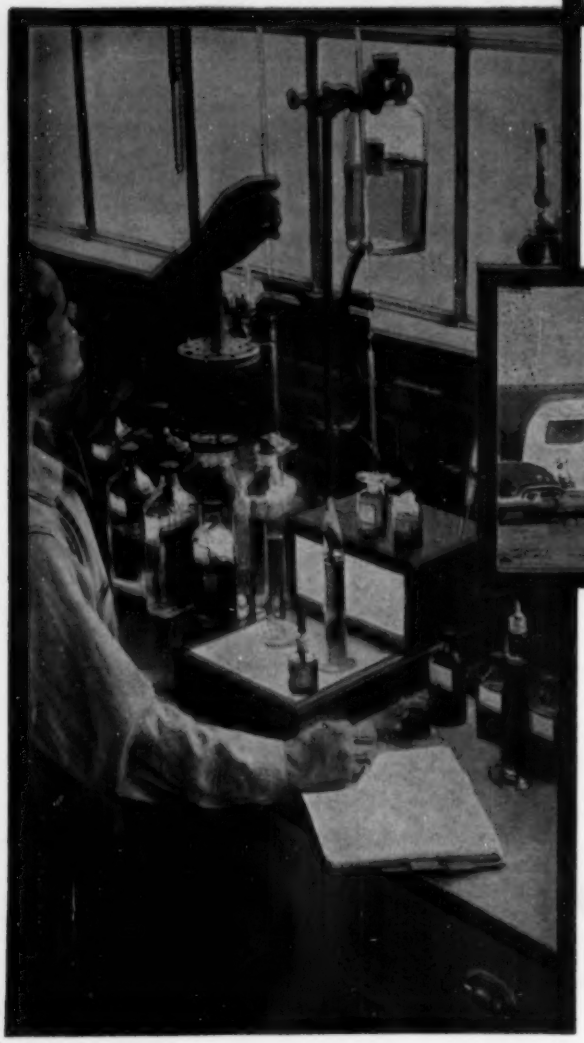
SUPPLY DIVISION – Tulsa

SERVING THE UNITED STATES AND CANADA

he's sure of the right answer...



Your Tretolite field engineer is sure of the right answer because he is properly equipped and carefully trained to apply the treating knowledge gained in Tretolite's many years of field experience. He also knows that he is backed by expert technical assistance, immediately available, and a research and development staff ready to move right out into the field, if necessary.



It is very seldom that a Tretolite field engineer has to go this deep to solve a problem, but if it is necessary, the best facilities in the world are available. That's why it pays to call your Tretolite service engineer—he offers products and services which are widely recognized as the best obtainable.

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A DIVISION OF PETROLITE CORPORATION

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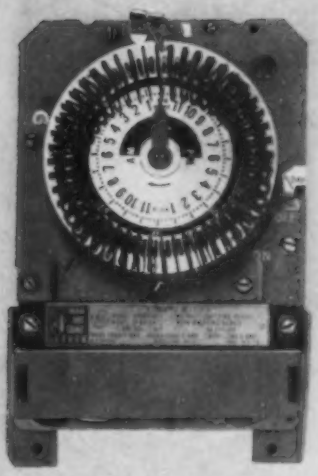
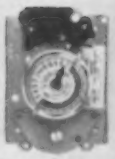


COMBINATION TIMER

1 DEVICE PERFORMS 2 FUNCTIONS

SEQUENCE TIMER



PROGRAM TIMER

NEW COMBINATION TIMER performs functions of program timing, and automatic sequence restart. It is now part of every G-E oil-well pumping starter.

NEW

Timer Now Standard on All G-E Oil-Well Pumping Starters

G-E oil-well pumping starters are now equipped with the new G-E combination timer. Because this device combines in one unit the functions of program timing, and automatic sequence restart, it has gained wide acceptance in the oil fields. This new timer design means big savings in time and easier operation.

Program timing is especially easy. Toggle tabs which flip toward the center of the dial make control of ON-OFF operation a simple matter, even with a gloved hand. Tabs are spaced at half-hour intervals to make tab settings easy. If desired, the toggle tabs can be moved for 15-minute pumping periods.

Automatic sequence restart provided by the timer helps prevent overloading of the power supply when several motors restart at the same time after power failure. No settings or adjustments are necessary. Momentary contacts, which are closed for only a few seconds out of every four minutes, control sequence restart. After a power failure, the pumping motor will start only when these contacts are closed and the program tabs call for pumping.

Other outstanding features make the G-E oil-well pumping starter the best you can buy. Some of these features are:

- High drop-out undervoltage relay better protects motor windings. If line voltage drops to approximately 70 percent, the undervoltage relay opens the line contactor, and helps prevent overheating the motor.
- Undervoltage relay circuit provides better "single phasing" protection. Loss of power on any line prevents the controller from energizing the motor under single-phase conditions.
- Gasketed starter enclosure is designed to keep out dust, snow, sleet and rain.
- Separate ventilated overload relay compartment reduces the possibility of unnecessary tripping due to excess heat from the sun.
- 15-minute definite-sequence restart timer is available for use where a demand charge is made by the utility company.

GENERAL ELECTRIC

SEE THIS NEW OIL-WELL PUMPING STARTER AT YOUR NEAREST G-E APPARATUS SALES OFFICE OR DISTRIBUTOR—OR SEND IN COUPON BELOW.

SECTION A733-4
GENERAL ELECTRIC COMPANY
BOX 913, BLOOMINGTON, ILL.

Please send me a copy of your new bulletin GEA-6410, covering control for oil-well pumping. I want this for:

☐ reference only ☐ immediate project

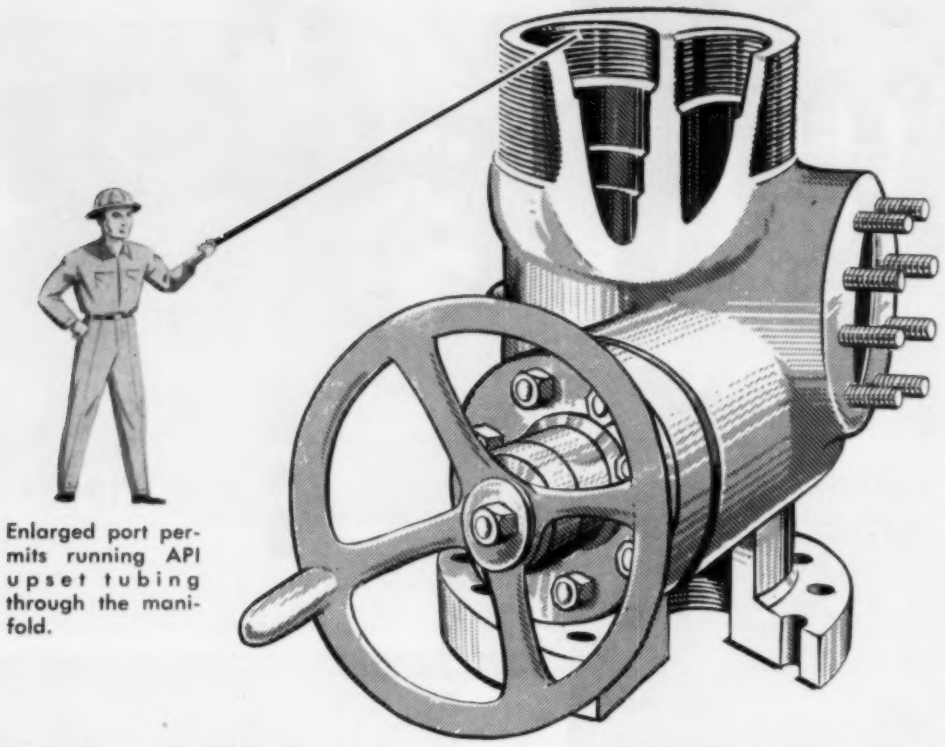
NAME.....

COMPANY.....

TITLE.....

STREET.....

CITY..... STATE.....



Enlarged port permits running API upset tubing through the manifold.

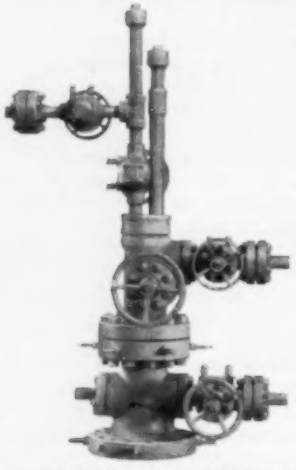
ADDITIONAL REVENUE from the SAME HOLE with the McEvoy DUAL BORE INTEGRAL MANIFOLD

which allows shallow sand production without interfering with a deep completion

FOUR EXCLUSIVE FEATURES OF THE McEvoy DUAL BORE INTEGRAL MANIFOLD

1 Combines a Tubing Head Adapter, Master Valve and Flanged Tee to provide a compact, economical unit for completion of the deep sand, with less expensive screwed equipment for the shallow sand.

2 API Casing Thread at the top end of the valve provides a means for mounting blowout preventers for completing the shallow sand.



3 Permits running the second string of tubing into the casing **after** completing in the deep sand. Permits pulling second string **without disturbing** flow of deep sand.

4 Standard upset or integral joint tubing, for producing the upper sand, can be run **through the port of the manifold.**

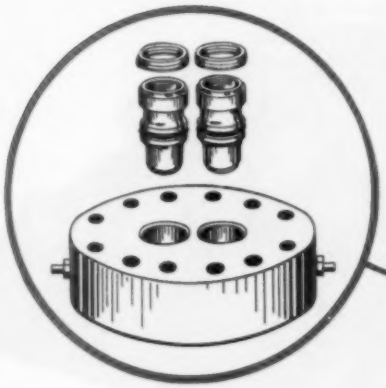
ONE OF MANY McEVOY MULTIPLE TREES ALLOWING **FULL VERTICAL ACCESS** TO ALL TUBING STRINGS.

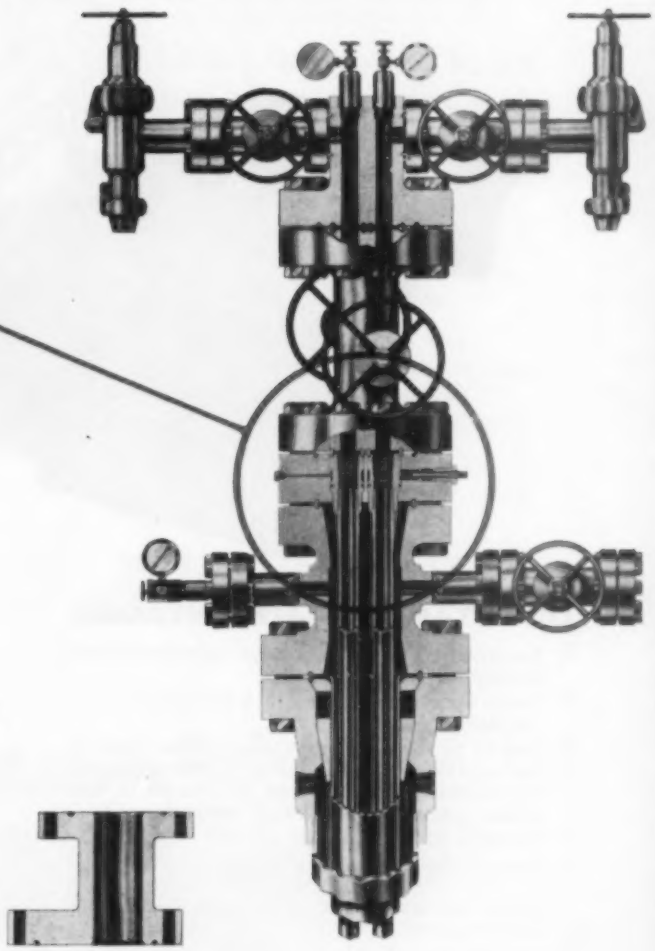
1906 McEvoy COMPANY 1956

TEXAS AND MILBY ST. P. O. BOX 3127 HOUSTON 1, TEXAS Pat. & Patents Pending

RECTOR Dual-String Hanger Flange

Outstanding Simplicity and Flexibility, plus the FAMOUS Rector Metal-to-Metal Seal





SIMPLICITY: The flange has two full opening tapered bores in which the strings are suspended by threaded mandrels. This eliminates mating and sealing two tubing hangers in a single, large bore. Each string can be suspended, temporarily sealed, and held down independently of the other assuring maximum ease of installation with complete control of well.

FLEXIBILITY: Regular 2" API upset tubing can be run or pulled through the bores in the flange.

METAL-to-METAL SEALS: Each mandrel is independently sealed by a metal seal ring in the groove at the junction of mandrel and flange. This metal-to-metal sealing arrangement also acts as a hold-down. "O" Rings on the mandrel provide a temporary seal during completion and permit testing the seal after Christmas Tree is installed. Mandrels are grooved for hold-down locking screws, which are optional in the flange.

• **Rector Dual-String Hanger Flanges are available in Nom 6 and Nom 8 sizes in any series. Mandrels are interchangeable.**

For maximum simplicity and flexibility of dual-string suspension, plus the metal-to-metal seal that never requires maintenance or replacement, specify a Rector Dual-String Hanger Flange in your dual completion Christmas Tree.

Off-Set Adapter Spool permits use of regular preventer equipment with alignment directly over each individual bore while running and pulling tubing. After first string is run, Adapter Spool can be rotated to center directly over the other bore.

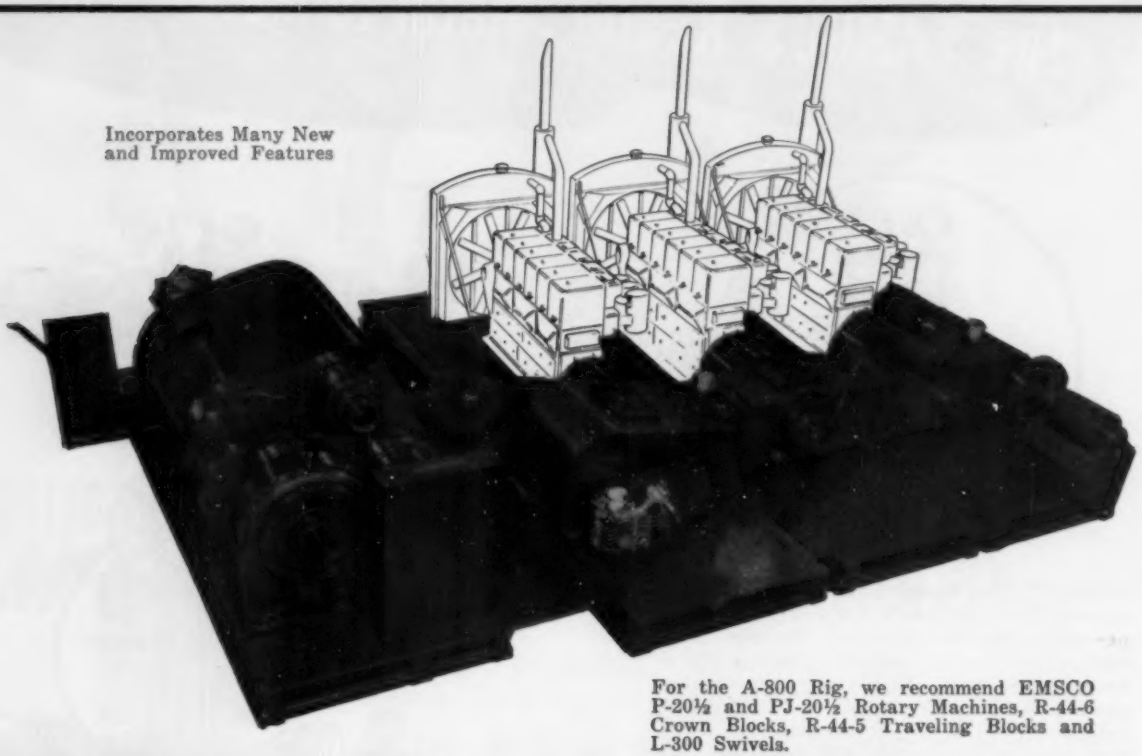
RECTOR WELL EQUIPMENT COMPANY INC
★ MAKING THE OIL INDUSTRY SAFER
1100 NORTH COMMERCE ST. FORT WORTH, TEXAS
Houston Plant: 2215 Commerce St.
REPRESENTATIVES IN ALL ACTIVE FIELDS

Complete "Packaged Portability" with

THE AMAZING NEW EMSCO A-800 RIG

designed to slash operating costs

Incorporates Many New and Improved Features



For the A-800 Rig, we recommend EMSCO P-20½ and PJ-20½ Rotary Machines, R-44-6 Crown Blocks, R-44-5 Traveling Blocks and L-300 Swivels.

OUTSTANDING ADVANTAGES

1. Designed especially to reduce operating costs on medium to deep wells.
2. Ships easily on 4 trucks in 4 convenient "packages."
3. Can be powered by any three drilling engines having a total power output of 1,000 h.p. Engine to transmission drives may be Fawick clutch, torque converter or hydraulic coupling.
4. Drum is 24" in diameter and 50" long.
5. Selective transmission is in No. 1 engine package. Output shaft of the sectional type compound and input shaft of the selective are one and the same.
6. Greatly improved and simplified brake cooling system.
7. New friction-compounding clutch saves operator time.
8. Highly effective lubrication system.

Another Major EMSCO Help for the Drilling Contractor

Effectively sealed from entry of mud or other foreign material, EMSCO P Rotary Machines are superior in design and construction and built for long life and quiet performance.

Learn more about the new EMSCO A-800 Rig and EMSCO P Rotary Machines. Call CONTINENTAL today for complete information.

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Serving the Oil and Gas Industries

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R-602

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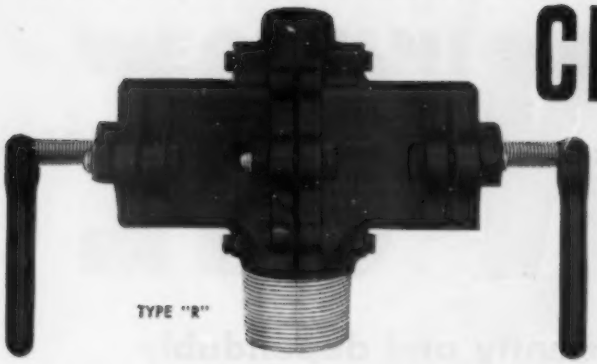
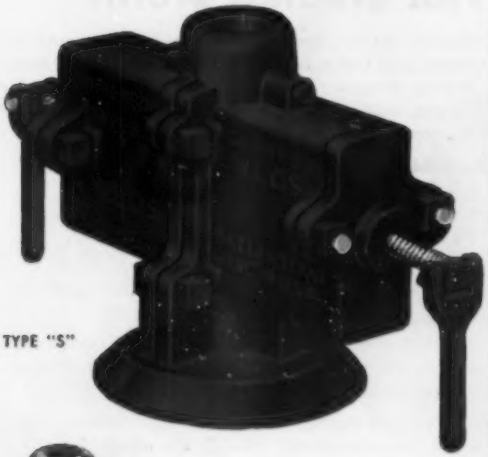
CLEAN FLOOR SAFE DERRICK



TYPE "R"



TYPE "S"

TYPE "D"

TYPE "B" RELEASING ATTACHMENT

GUIBERSON *Wire Line Oil Savers*

for Excellent Pack-Off—Clean, Dry Line

3 to choose from—take your choice and know that if it's Guiberson, it's *good!*

TYPE "R"—for tubing. Simple, inexpensive, effective. Split housing for easy installation.

TYPE "S"—for casing or tubing. Economical, simple—similar to "R" but heavier construction, flange bottom or tubing connection.

TYPE "D"—for tubing or casing. Two independent sets of rubbers, single end operation, make it cost more but still very economical. Pin or flange adapter connection.

Non-sparking brass bushings and guides throughout . . . long-wearing rubbers . . . finest Guiberson precision construction.

TYPE "B" RELEASING ATTACHMENT—
Positive release for Oil Savers—prevents tool damage.
Easy to attach, pressure won't release it.

Better Be Safe Than Sorry!

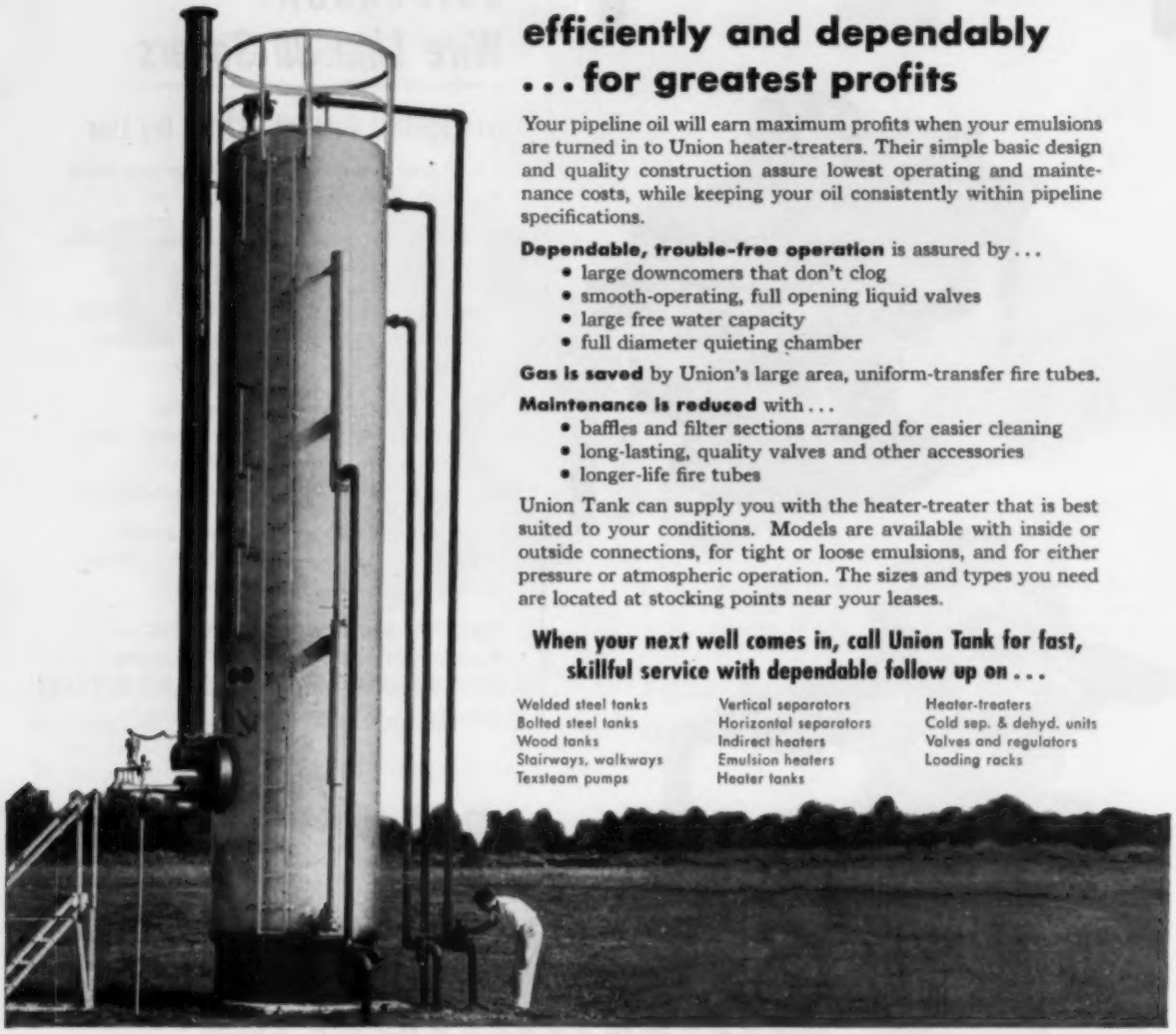
THE
GUIBERSON
CORPORATION

ESTABLISHED 1919 • DALLAS, TEXAS, U. S. A.

Sold By Leading Oil Field Supply Stores Everywhere

Call **UNION TANK** for heater-treaters that produce

CLEAN OIL



efficiently and dependably ... for greatest profits

Your pipeline oil will earn maximum profits when your emulsions are turned in to Union heater-treaters. Their simple basic design and quality construction assure lowest operating and maintenance costs, while keeping your oil consistently within pipeline specifications.

Dependable, trouble-free operation is assured by ...

- large downcomers that don't clog
- smooth-operating, full opening liquid valves
- large free water capacity
- full diameter quieting chamber

Gas is saved by Union's large area, uniform-transfer fire tubes.

Maintenance is reduced with ...

- baffles and filter sections arranged for easier cleaning
- long-lasting, quality valves and other accessories
- longer-life fire tubes

Union Tank can supply you with the heater-treater that is best suited to your conditions. Models are available with inside or outside connections, for tight or loose emulsions, and for either pressure or atmospheric operation. The sizes and types you need are located at stocking points near your leases.

When your next well comes in, call Union Tank for fast, skillful service with dependable follow up on ...

Welded steel tanks	Vertical separators	Heater-treaters
Bolted steel tanks	Horizontal separators	Cold sep. & dehyd. units
Wood tanks	Indirect heaters	Valves and regulators
Stairways, walkways	Emulsion heaters	Loading racks
Texsteam pumps	Heater tanks	

WORLD WIDE SERVICE
UNION
TANK & SUPPLY CO.

UNION TANK AND SUPPLY COMPANY

P. O. Box 2092, Houston, Texas

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Dallas, Texas	Dubach, La.	Plainville, Kan.	Casper, Wyo.
Fort Worth, Texas	LaFayette, La.	Russell, Kan.	Newcastle, Wyo.
Houston, Texas	New Orleans, La.	Wichita, Kan.	Powell, Wyo.
Kilgore, Texas	Ardmore, Okla.	Kimball, Nebr.	Williston, N. D.
Midland, Texas	Cushing, Okla.	Sidney, Nebr.	Glendive, Mont.

BUTLER STEEL PRODUCTS

Union Tank and Supply Company is a subsidiary of the Butler Manufacturing Company, Kansas City, Missouri

WECO UNIONS...

Meet Service Company Requirements to a... t

Fracturing, cementing, and acidizing demand a union that can take it . .

These services require a union that makes-up and breaks-out fast, a union that seals securely on job after job, a union that withstands the severe abrasive action and extremely high pressures and volumes of these operations.

And WECO Unions can take it. Their famous ball and cone seat forms a positive, leak-proof seal . . . their rugged Acme threads make-up and break-out fast . . . their extra tough sub ends and wing nuts take constant abuse—and ask for more—day after day.

• *Because WECO Unions fulfill these demanding requirements so successfully they are used by the majority of service companies.*

U-16-55

WELL EQUIPMENT MFG. CORP.
HOUSTON, TEXAS

Division of CHIKSAN COMPANY *a subsidiary of*
FOOD MACHINERY AND CHEMICAL CORPORATION

WECO®

This is the Baker Model "F" Drill Pipe Float Valve, Product No. 4813—available at your supply store

one of the *Best Friends* a contractor ever had...

Through the years, suggestions of drilling contractors and drilling department personnel have been of great help in re-designing and improving **BAKER DRILL PIPE FLOAT VALVES** until today they are considered an old and trusted friend in the majority of drilling strings.

WHY THIS "OLD FRIEND" IS WELCOME ON DRILLING RIGS

1. It eliminates plugged bits, and avoids pulling wet strings—no muss or fuss;

2. A "float valve" in the drilling string is mighty cheap insurance in event the drilling string parts;

3. The strong, simple valve is merely dropped into place, either in a recess in the drill collar, or in a Drill Pipe Float BODY at any point in the string;

4. It is easily installed without tools or wrenches, and the inexpensive replacement parts are available at any supply store for servicing right on the derrick floor.

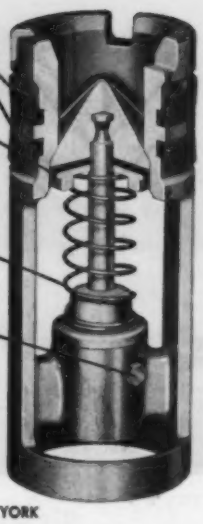
FEATURES

REVERSED SIDE SEALS
prevent distortion of the seals by trapped fluid.

MORE EFFECTIVE SEALING
The re-designed seal between the valve and the valve seat seals better—lasts longer—stays in place even under high circulating volumes and high pressures.

LESS SPRING TENSION
reduces the cutting action of circulating fluid on the valve seal and seat.

GUIDE POSITIVELY ANCHORED
The valve guide is held securely in place by a set screw.



BAKER OIL TOOLS, INC. HOUSTON • LOS ANGELES • NEW YORK

BAKER DRILL PIPE FLOAT VALVE

Industry has spent $153 million on 246 of these super-deep holes — one-third of it in 1955 . . . Ten fields are producing from these depths

80 Wells Completed Below 15,000 ft in 1955

AVERAGE DEEP WELL
(Below 15,000 ft)

- **Depth . . . . . 15,947 ft**
- **Drilling time . . . . . 192 days**
- **Number bits . . . . . 126 bits**
- **Mud cost. $85,000**
- **Well cost $623,000**
- **Chances of being producer . . 51%**

Ernestine Adams*

THE petroleum industry spent $50 million in 1955 alone on wells drilled 15,000 ft and deeper. This brings the total spent on these deep wells to more than $150 million.

Until last year, 166 wells reached the 15,000 ft depth in the 11 years when any were drilled. In 1955 another one-third—80 wells—went to these depths and were completed before the end of the year, making a total of 246 wells.

Besides these a number of wells had drilled below 15,000 ft in 1955 but were not completed until after the first of the year or are testing, suspended or waiting on completion.

It is hard to decide which figures are the important ones in this tenth annual survey on deep wells. The number drilled shows a decided trend toward deeper exploration.

The number of operators indicates the greater willingness to go after deeper production. The number of drilling contractors involved shows the wider ownership of modern heavy drilling machinery and equipment.

Cost figures fluctuate because in the past the numbers have been so small that one or two of the $2 or $2½ million deep ones raised the average.

For the last three years, when the number of wells has increased rapidly, the cost has declined on the average. In 1953 the average well below 15,000 ft was $685,000. In 1954 costs have been adjusted upward. A number of cost figures, mostly on the high side, were not in when the report was made in January last year. The figure is $676,000 average per well.

Last year the cost per well came

*Management Editor.

TABLE 1. NUMBER OF WELLS DRILLED BELOW 15,000 FT BY YEARS OF COMPLETION.

Year	Wells drilled below 15,000 ft by date of completion	Average drilling time	Average bits per well	Mud costs, average	Well costs, average	Average depth	Deepest well	Deepest producer
1938	1	284	195	—	—	15,004	15,004	13,175
1945	4	490	222	—	—	15,870	16,655	13,175
1946	1	349	184	—	—	15,452	16,655	13,175
1947	8	267	181	$23,500	$570,000	15,891	17,823	13,904
1948	7	328	303	27,500	551,000	16,047	17,823	14,255
1949	11	222	199	62,500	534,000	16,421	20,521	15,530
1950	5	235	181	63,000	577,000	15,713	20,521	15,530
1951	12	178	116	54,000	521,000	15,822	20,521	15,530
1952	24	212	138	66,000	542,000	15,874	20,521	16,102
1953	34	229	150	79,000	685,000	16,127	21,482*	17,895
1954	59	182	116	72,000	676,000	15,883	21,482	17,895
1955	80	150	85	123,000	617,000	15,957	22,559*	17,895

*Not completed by end of year but record depth made.

TABLE 2. LOCATION AND AVERAGES OF WELLS DRILLED BELOW 15,000 FT.

State	Number wells 1955	Total 15,000 ft holes	Completed as producers	Drilling time average days	Average bits per well	Deepest hole	Mud costs, average	Well costs, average
Alabama	0	1	0	225	186	15,659	—	—
California	9	25	7	191	176	21,482	$76,000	$ 776,000
Colorado	0	1	1	420	322	15,041	—	—
Florida	0	1	0	485	144	15,155	—	—
Louisiana	57	145	88	135	82	22,570[2]	79,000	537,000
Mississippi	2	6	2	278	178	20,450[1]	71,000	575,000
New Mexico	1	5	5	364	260	16,459	176,000	1,003,000
Oklahoma	1[3]	8	3	424	285	17,823	87,000	650,000
Texas	10	50	16	253	171	18,609	98,000	726,000
Wyoming	0	4	2	379	286	20,521	86,000	800,000
TOTALS	80	246	124	192	126	22,570	85,000	$ 623,000

[1]George Vasen No. 1 Fee which has not been completed.
[2]Richardson & Bass LL&E No. 1-L, State Lease 2414, world's deepest hole, now testing.
[3]This Oklahoma well was not completed in 1955 as at first reported.

TABLE 3. FIELDS WITH PRODUCTION BELOW 15,000 FT.

Field	County or parish	State	Producing wells below 15,000 ft	Deepest production, ft
North Coles Levee	Kern	California	1	17,895
Wasco	Kern	California	1	15,530
Weeks Island	Iberia	Louisiana	24	17,745
Cote Blanche Island	St. Mary	Louisiana	4	16,415
Queen Bess Island	Jefferson	Louisiana	2	15,481
Dog Lake	Terrebonne	Louisiana	1	15,573
Lake Washington	Plaquemines	Louisiana	1	15,138
San Simon	Lea	New Mexico	1	15,025
Puckett-Ellenburger	Pecos	Texas	3	15,324
West Poison Spider	Natrona	Wyoming	2	16,102

TABLE 4. PRODUCING DEPTHS OF WELLS DRILLED BELOW 15,000 FT.

Producing depth, ft	No. producers	Producing depth, ft	No. producers
2- 3,000	1	11-12,000	5
4- 5,000	1	12-13,000	14
5- 6,000	2	13-14,000	23
6- 7,000	4	14-15,000	19
7- 8,000	4	15-16,000	25
8- 9,000	6	16-17,000	7
9-10,000	3	17-18,000	8
10-11,000	3		
TOTAL PRODUCERS			124

down to $617,000. This does not, however, include the record Richardson and Bass well which reached a total depth of 22,570 ft but is not completed.

Average cost of all wells drilled below 15,000 ft runs about $623,000 per well.

Production Found

Results of the 80 wells drilled in 1955 were higher than average, as they should be with greater vertical areas of exploration. They came out something like this:

10 new fields discovered out of 39 wildcats drilled
plus
16 new sands or extensions out of 50 wildcats and semi-wildcats,
and
15 new development wells producing out of 30 field wells drilled.

Of the 10 new fields, 4 are new gas fields now shut in — part of the slowdown of gas development since Federal Power Commission was given control over natural gas production.

Six of the new fields are in Louisiana, two in Mississippi, one each in Texas and New Mexico. Below are listed the new fields discovered by wells drilled 15,000 ft or deeper.

1. Continental Oil State Unit 953 No. A-1, Grande Isle area, Jefferson Parish, Louisiana; 15,058 TD with dual completion. IP 348 b/d and 222 MCF from 9868-74 and 411 b/d and 1028 MCF from 13,614-20 ft.

2. Superior Oil LL&E State Unit 9 No. 4, Four Isle, Terrebonne Parish, Louisiana, 15,134 ft. IP 176 b/d 52.3 API, 8528 MCF from 14,908-948 ft. Shut in.

3. Cities Production Company Brownell-Kidd No. 1, Bay Natchez, Assumption Parish, Louisiana, 15,205 ft, IP 63 b/d 45.2 API, 2320 MCF from 13,638-48 ft.

4. Union Oil & Gas Company of Louisiana, Miles Timber No. 1, 40 miles West of New Orleans, St. James Parish, Louisiana, 17,297 ft. IP 162 b/d, 3400 MCF from 11,218-28 ft.

5. Shell Oil Caffery et al No. 1, Cote Blanche Island, St. Mary Parish, Louisiana, 16,479 ft. IP 33 b/d, 41 gravity, 1800 MCF from 16,410-15 ft. Shut in.

6. Superior Oil Harry Bourg No. 1, South of DeLarge area, Terrebonne Parish, Louisiana, 15,881 ft. Production depth 14,982-94 ft. Gas condensate well shut in.

7. Continental Oil Bell Lakes No. 1-A, San Simon Sink area, Deleware Basin, Lea County, New Mexico, 15, 120 ft. IP 15.5 MCF from 14,942-15,025 ft.

8. Magnolia Petroleum West Ranch A-417, Jackson County, Texas, 19,060 ft. Dual completion 53 b/d from 5105-15 ft and 9600 MCF from 4539-51 ft.

9. S. W. Richardson Walker No. 1, Gwinville area, Jefferson Davis County, Mississippi, 18,629 ft. IP 895 MCF from 8150-6 ft. Shut in.

10. Sun Oil Southern Package No. 1, Copiah County, Mississippi, 15,207 ft. IP 20 b/d condensate, 900 MCF from 14,930-80 ft.

The deepest production in Oklahoma was being tested by British-American in Grady County. It will be in the 1956 list. Oil and gas come from several sands, one below 15,300 ft.

One of the field extensions in 1955 was to Sanborn field in Matagorda County, Texas, by Stanolind.

ACKNOWLEDGMENT

Deep-drilling operators have generously supplied valuable data on wells in this tenth annual survey of deep drilling. We fully appreciate the amount of effort required to give us this fine cooperation and hope that the operators receive full benefit from this shared information.

Because of the great expense involved in this type of drilling, information that helps to plan and execute such a project is worth study. No operator lightly consigns more than a half million dollars to one well; data here should provide some guidance.

Shell completed five extensions to Weeks Island field and discovered a new sand at Cote Blanche Island field, Louisiana.

Also in Louisiana, Sun extended Belle Isle field; Superior found a new sand at Constance Bayou; Richardson and Bass discovered a new sand at Little Lake field. Union Producing extended Deep Lake field and M. L. Mayfield extended Amelia field. A new sand was found at Church Point field by Pan-American Production Company.

Placid Oil Company drilled two extensions to Lake Washington field, Louisiana, and John W. Mecom found a new sand there. This is the area where the deep Richardson and Bass well is testing.

Deep Fields

Wells produce from formations below 15,000 ft in 10 deep fields, one being added in 1955.

Weeks Island field still leads the deep fields. It is the largest producing field in Louisiana and has 23 wells producing from 15,000 to 17,745 ft. Shell, Humble, Texas, and other companies operate on this salt dome structure of liquid treasure.

The new deep production is at San Simon in Lea County, New Mexico. This is also a new field discovered by Continental Oil and not just a deeper extension of an old field.

Table 3 gives a list of these deep fields, half of which are in Louisiana.

Most producing depths are above 15,000 ft as shown in Table 4. Out of 124 producers only 40 produce from below 15,000 ft.

Drilling Time

Average drilling time per well has also declined steadily in the last three years as well completions went up. In 1953 it was 229; in 1954, it was 182, and in 1955, an average of 150 days was required for drilling only.

Drilling time averages for all wells below 15,000 ft is 192 days.

So far the record time was made by Penrod Drilling Company in Louisi-

TABLE 5. DESCRIPTION OF WELLS IN THE UNITED STATES DRILLED BELOW 15,000 FT

TD, ft; Prod. depth	Company Well	Drilled by	Field; County or parish	Completed; Spudded	Mud program	Bits, rock, drag and diamond	Cores; Drillstem tests	Perforations in prod. zones	IP, gravity, choke, T press.	Remarks
				CALIFORNIA						
15,157 D & A	Standard of Calif. Vanderkarr #1	Drilling & Exploration	Santa Paula Ventura	4-21-55 2- 8-55	Low pH, lignite emulsion					WC. Drilled to TD in 72 days.
15,299 D & A	General Petroleum Glide Court #65-10	K. L. Kellogg	Wildcat Yolo	8-31-55 4-17-55	Special treated water-base clay, mud compounded to give low % solids by volume.	131R	7C			WC. Deepest test in Sacramento Valley.
15,539 13,138	Standard of Calif. McGrath #1-1013	Rocky Mt. Drilling Co.	W. Montalvo Ventura	2-18-55 10- 4-54						FW. Plugged back to 13,138'. Completed with combination jet and bullet perforations.
15,550 D & A	Standard of Calif. Yuba Consol. #1	Drilling & Exploration	Fillmore Ventura	8-19-55 5-28-55						WC
15,979 D & A	Standard of Calif. Hardison Ranch #2-2	Rocky Mt. Drilling Co.	Wildcat Ventura	8-17-55 2-10-55	Low pH, lignite emulsion	183R	10C 1DS			WC.
16,075 D & A	General Petroleum Edwards #1	Thos. P. Pike Drilling Co.	Wildcat Ventura	5 -8-55 1-18-55	Clay-base to 15,530', oil emulsion to TD	140R	14C			WC.
16,100 D & A	Standard of Calif. Sespe Creek #1	Rocky Mt. Drilling Co.	Fillmore Ventrua	6- -55	Low pH lignite emulsion	109R	8C			WC.
16,492 D & A	Lloyd Corp. Wm. Sexton #1	Drilling & Exploration	Ventura Ave. Ventura	1-10-55 7- 3-54						WC. Redrilled from 2000'.
16,639 D & A	Humble Oil & Ref. Paul J. Leavens et al	Loffland Bros.	Wildcat Ventura	10- 3-55 8- 4-55	Phosphate-caustic soda-Quebracho oil emulsion	69R	1C			WC. Drilled to TD in 61 days.
				LOUISIANA						
15,000 D & A	Texas Gulf Feitel et al # 1	Loffland Bros.	Shell Island St. Mary	7-12-55 4- 2-55	Phos. to 11,000', lime oil emulsion below.	44R 1Dr	33SW cores			WC.
15,000 D & A	Sun Oil Co. J. B. Blanchard #1		Humphreys Terrebonne	3- 3-55 11- 6-54	Lime-treated oil emulsion 9850'—TD 17.1#	48R 2Dr				WC.
15,017 13,106	Sun Oil Co. Dibert Stark & Brown #43		Chacahoula Lafourche	5-24-55 12- 8-54	Lime-treated oil emulsion, 10,600—TD 16.8#	105 total		13,096- 13,106	173 B, 49.2°, ¼", 3250#	FW.
15,036 D & A	Pure Oil Co. F. Blanchard #1	Delta Gulf Drilling Co.	Willow Lake Cameron	1-10-55 7-30-54	Lime-base 12% oil emulsion below 8500'					WC.
15,058 13,620	Continental Oil State Lse. 953 #A-1		Grande Isle Jefferson	12-12-55 3- 1-55				9,868- 9,874 13,614- 13,620	348 B, 222 MCF, 1665# 411 B, 1028 MCF, 3500#	WC. New field discovery in miocene 26' upper sand to 15' lower sand.
15,065 2,953	Humble LL & E "O" #2		Leeville Lafourche	12-22-55 7- 7-55				2,940- 2,953	814 MCF, ⅝", 1150#	FW. Recovered fish 12,080. PB to 3100. Shut-in gas well.
15,117 J & A	Texas Co. F. E. Roshto et al #A-1		Sorrento Ascension	3-29-55 12- 4-54						FW. Plugged back to 11,760' after failing to recover fish.
15,131 13,200	Superior Oil E. P. Frymire et al #1	Company rig	E. Lk. Palourde Assumption	4- 9-55 12-21-54			68SW	13,166- 13,200	245 B, 9380 MCF, 13/64", 4075#	FW. 92 days to drill to TD.
15,134 14,948	Superior Oil LL & E St. Lse 9 #4	Company rig	Four Isle Terrebonne	3-25-55 8-30-54				14,908- 14,948	176 B, 52.3°-8528 MCF, 13/64", 3383#	WC. New gas-cond. discovery now shut in.
15,170 14,510	Union Producing Rockefeller #5		Deep Lake Cameron	12-18-55 6-25-55				14,465- 14,510	35,000 MCF, ¼", 5125#	WC. New gas field. Thru ½" ck. flowed 10,140 MCF. Shut-in.
15,177 13,451	Placid Oil Co. LL & E Unit 13 #6		L. Washington Plaquemines	11-12-55 9-14-55	Coverted to lime-base starch and oil emulsion at 9000'	38R 2Dr	70SW	12,875- 12,895 13,440- 13,451	324 B, 26.5°, 1/2", 1650# 216 B, 28.6°, ¼", 3050#	FW. Dual completion. Record drilling time of 37 days.
15,205 13,648	Cities Production Co. Brownell-Kidd #1	C. B. Webster Drilling Co.	Bay Natches Assumption	5- 7-55			1C 3DS	13,638- 13,648	63 B, 45.2°-2320 MCF, 1/2", 8000#	WC. New field discovery in miocene 55' thick. 90 days to drill.
15,230 14,349	Texas Co. E. B. Boyne et al #1		Caillou Terrebonne	5-24-55 1-10-55				14,343- 14,349	286 B, 32°, 2000#	FW.
15,282 D & A	Stanolind State Lse. 748 #1	Dixie Drilling Co.	Ship Shoal Terrebonne	2-23-55 9-11-54	Lime-base oil emulsion 15.8# max.		101SW			WC.
15,285 Temp A	H. L. Hawkins M. C. MacDonnell #1		S. Lake Arthur Vermilion	8- 2-55 3-13-55						WC. Fishing job at 15,150'.
15,300 13,176	Texas Co. State Lse. 301 #98		Caillou Terrebonne	10-31-55 9- 5-55				13,168- 13,176	185 B, 1600#	FW. PB to 13,200'.
15,305 13,606	Placid Oil Co. LL & E Unit 13 #3	Penrod Drilling Co.	L. Washington Plaquemines	1-10-55 11-10-55		44R	40C	13,556- 13,606	260 B, 25.5°, 11/64", 1300#	FW. Extended field. Drilled in 45 days.
15,324 10,260	Richardson & Bass St. Lse. 2453 #B-11	Company rig	Little Lake Jefferson	11-20-55 7-23-55	Red mud to 12,088 lime-base to TD			10,252- 10,260	195 B, 116 MCF, 1400#	WC. Discovered new sand in miocene. Drilled in 82 days.
15,340 15,165	Shell-Weeks Gall State Unit 4 #1	Company rig	Weeks Island Iberia	3- 8-55 12-18-54	Red mud	51 total		15,145- 15,165	325 B, 32°-399 MCF, 5/64", 2400#	FW. Extended famous Weeks Is. field. Drilled in 55 days.

TABLE 5. DESCRIPTION OF WELLS IN THE UNITED STATES DRILLED BELOW 15,000 *(Continued)*

TD, Prod. depth	Company Well	Drilled by	Field; County or parish	Completed; Spudded	Mud program	Bits, rock, drag and diamond	Cores; Drillstem tests	Perforations in prod. zones	IP, gravity, choke, T press.	Remarks
			LOUISIANA (Continued)							
15,466 D & A	Max Pray Wilberts Lbr. #1	Rowan Drilling Co.	Bayou Bouillon Iberville	9-15-55						WC.
15,448 Temp A	Stanolind LL & E #1	Prince Drilling Co.	Bastian Bay Plaquemines	12-13-55 6- 5-55						WC. Failed to recover fish—PB to 12,533. Had shows of oil & gas.
15,450 15,369	Texas Co. St. Lse. 2084 Unit #1		Queen Bess Is. Jefferson	5-18-55 3- 1-55				15,353-15,369	41 B, 45.7°, 16/64", 5350#	FW
15,462 P & A	Houston Oil Chas. H. Wright #1		S. Mermentau Acadia	12- 4-55 8-24-55					none	WC. Shows of oil & gas.
15,469 14,258	Texas Co. LL & E Leeville #167		Leeville Lafourche	6- 3-55 11-19-54				14,238-14,258	227 B, 29.5°, 7/64"	FW in Leeville field.
15,500 13,984	John W. Mecom et al LL & E Unit A #1	C. G. Glasscock Drilling Co.	L. Washington Plaquemines	5-18-55 1- 2-55	Lime-base oil emulsion	60R 1Dr	19C	13,978-13,984	211 B, 35.5°, 13/64", 900#	WC. New sand 72' thick, east of Lake Washington field. Drilled in 83 days.
15,500 12,078	Sun Oil Co. St. Mary Land #1		Belle Isle St. Mary	8-13-55 2-16-55	Lime-treated oil emulsion, 8900' to TD 17.8#	10Dr 63R	6DS	12,074-12,078	Gas well ungaged	WC. Discovered new sand and extended Belle Isle field. Shut-in.
15,500 D & A	Humble State Lse. 2433 LL & E #1		Charlies Bayou Plaquemines	1-25-55 11-17-54						
15,522 D & A	Stanolind State Lse 747 #A-1	Dixie Drilling Co.	Ship Shoal #24 Terrebonne	8-24-55 5-10-55	Lime-base oil emulsion 13.2# max.	77R	58SW			WC. Lost circulation at 11,331' and 12,891' in shale.
15,525 P & A	J. P. Owen L. B. Lawson #1	Owen Drilling Co.	Acadia	3-13-55 10- 7-54	Lime-base oil emulsion	58R 2Dr	21SW			WC.
15,568 Temp A	Lamson, Bennett, Cole Nugier Unit #1		Deer Bayou Vermilion	11-14-55 6-18-55			14SW			WC. Well tried to blowout at 14,512'—killed with 17# mud.
15,568 D & A	Texas Co. La Terre Co. #55		Golden Meadow Lafourche	2- 6- 55 9-25-54						
15,571 Shut-in	M. L. Mayfield Co. L. Moore Lbr. Co. #2	Offshore Drilling Co.	Amelia Assumption	1- 8-55 6-30-54						FW. Extended Amelia field. Shut-in gas well.
15,632 15,586	Shell Oil, Smith State Unit D #3	Company rig	Weeks Island Iberia	8-25-55 6- 8-55	Red mud	61 total	0	15,571-15,586	350 B, 33.6°-531 MCF, 5/64", 2900#	FW. Extended Weeks Island field, a salt dome structure.
15,660 Temp A	John W. Mecom et al State Lse. 2277 #1	Company rig	L. Washington Plaquemines	3-30-55 10- 8-54	Lime-base	59R 1Dr	20C			WC. Drilled on salt dome structure.
15,753 D & A	Shell-Weeks Gall State Unit 5 #1	Company rig	Weeks Island Iberia	11-10-55 8-26-55	Red mud to 14,000' lime mud to TD	62 total	10C			FW. Drilled in 77 days.
15,847 J & A	Flaitz & Mitchell Martin #1		Section 28 St. Martin	11- 3-55 5-30-55			20SW			WC.
15,880 D & A	Sun Oil Co. Lyric Realty #1-B		Chacahoula Terrebonne	6- 7-55 6-29-54	Lime-treated oil emulsion, 9100' to TD 17.9#		4DS			FW. Drilled orig. hole in 63 days stk. hole in 153.
15,881 Shut-in	Superior Oil Harry Bourg #1	Company rig	De Large Terrebonne	12-16-55 4-15-55				14,982-14,994	Gas well, ungaged, TP 4600#	WC. Discovered gas-condensate field south of De Large. Shut-in.
15,910 11,418	Superior Oil Rockefeller #3	Company rig	Constance Bayou Cameron	11-23-55 4-21-55			12-hr DS	11,408-11,418	96 B, 47.3°-6528 MCF, 13/64"	FW. Shut-in.
15,948 15, 582	Shell Oil Smith St. Unit K #1	Company rig	Weeks Island Iberia	3-11-55 12-26-54	Red mud	61 total	8C	15,567-15,582	300 B, 32.7°-505 MCF, 2940#	FW in "T" sand, 15' thick. Drilled in 61 days.
16,000 13,314	Texas Co. State Lse. 1247 #4		Caillou Island Terrebonne	3-20-55 12-25-54				13,510-13,514	122 B, 31.0°, 4/64", 1325#	FW.
16,024 D & A	Mecom Freeport LL & E Lse. 2 #1	Company rig	Bay Baptiste Plaquemines	5- 7-55 1- 3-55	Lime base oil emulsion	90R 1Dr	28C			WC.
16,160 12,300	Pan American Prod. E. E. Daigle #3B	Gilger Drilling Co.	Church Point Acadia	6-10-55 2- 8-55	8000' to TD lime base oil emulsion	59R		12,290 12,300	150 B, 43.1° 2240 MCF, 16/64", 2500#	WC. Discovered new 20' sand in Church Point area.
16,273 14,280	Shell Oil Caffery et al #2	Company rig	Cote Blanche St. Mary	8-24-55 4-27-55	Salt saturated to 14,500', red oil emulsion to TD	52 total	21C	14,204-14,215 14,225-14,235	225 B, 33.5°-232 MCF, 13/64", 2150#	FW. Discovered new 21' sand in Cote Blanche Island field.
16,360 P & A	Richardson & Bass LL & E #1-B	Company rig	W. Bastian Bay Plaquemines	6-15-55 2-17-55	Red mud 4600'-14,100'; lime-base to TD	97 total				WC. 3½ miles S. E. of Lake Washington field.
16,414 14,928	Tide Water Assoc.		Venice Plaquemines	11-22-55 6- 2-55				14,920-14,928	116 B, 48.8°, 13/64", 2200#	FW.
16,479 16,415	Shell Oil Caffery et al #1	Company rig	Cote Blanche St. Mary	4- 8-55 10- 5-54	Salt saturated to 14,000'; red oil emulsion to TD	94 total	14C	16,410-16,415	33 B, 41°-1800 MCF, ½", 5450#	WC. Discovered new gas field. Shut-in.
16,535 fishing	Richardson & Bass LL&ESt. Lse. 2517 #1	John Mecom	Bay St. Elaine Terrebonne							WC. Twisted off at 15,396' and side tracked on 8-7-55.
16,906 16,752	Humble-Hortense Provost Gonsoulin #2		Weeks Island Iberia	5-18-55 3-19-55					273 B, 39.1°-321 MCF, ½", 2300#	FW.
17,000 na	Gulf Refining J. C. Henderson et al #4	Company rig	West Bay Plaquemines	7-17-55	18# low lime content oil emulsion	47 total	1C	na	na	WC. Found new field with testing in progress.
17,237 D & A	Texas Co. State Lse. 2436 #1		Lake Pelto Terrebonne	3-22-55 12- 8-54						FW.

TABLE 5. DESCRIPTION OF WELLS IN THE UNITED STATES DRILLED BELOW 15,000 *(Continued)*

TD ft; Prod. depth	Company Well	Drilled by	Field; County or parish	Completed; Spudded	Mud program	Bits, rock, drag and diamond	Cores; Drillstem tests	Perforations in prod. zones	IP, gravity, choke, T press.	Remarks
					LOUISIANA (Continued)					
17,297 11,228	Union O & G of La. Miles Timber Co. #1	Loffland Bros.	S. Vacherie St. James	9–12–55 3–28–55				11,218-11,228	162 B, 53.0°-3400 MCF, $^{15}/_{64}$", 3700#	WC. Discovered new field.
17,648 17,584	Shell Oil C. B. Patout et al #1	Company rig	Weeks Island Iberia	10–31–55 3– 9–55	Red mud to 15,500'; red oil emulsion to TD	151 total	11C	17,572-17,584	77 B, 40.5°-2901 MCF, 4800#	FW. Extended Weeks Island field. Deepest Gulf Coast producer. In "Y" sand.
17,681 17,460	Shell-Humble Druilhet #1	Company rig	Weeks Island Iberia	7– 5–55 3– 1–55	Red mud to 15,500'; red oil emulsion to TD	84 total	25C	17,452-17,460	192 B, 42.2°-6797 MCF, $^{14}/_{64}$", 4500#	FW. Drilled in 88 days. In "Y" sand.
17,780 17,445	Humble Juliet H. Provost #1		Weeks Island Iberia	3–18–55 10–28–54				17,440-17,445	81 B, 44°-2467 MCF, 5700#	FW. Lost DP in hole at 15,053'. Hole bridged at 14,840'.
17,867 P & A	Richardson & Bass LL & E #1-K	Company rig	L. Washington Plaquemines	2–12–55 10– 1–54	Lime-base mud 9436' to TD	72 total				WC. Stuck pipe at 14,131'.
18,503 16,149	Texas Co. State Lse. 356 #13		Queen Bess Is. Jefferson	7–21–55 8–22–54				16,120-16,149	Gas ungaged	FW. Shut-in gas well.
18,862 14,813	Texas Co. State Lse. 340 #26		Cote Blanche St. Mary	12– 3–55 5–13–55				14,807-14,813	262 B, 33.5°, $^{5}/_{64}$", 1400#	FW.
22,559	Richardson & Bass LL & E #1-L State Lse. 2414	Company rig	L. Washington Plaquemines	2–27–55	Red mud to 13,656'; lime-base to TD		3C			WC. Set world drilling record 11-9-55. Now testing.
					MISSISSIPPI					
15,207 14,980	Sun Oil Co. Southern Pkg. #1	Marshall R. Young	Wildcat Copiah	5–12–55 10–18–54	Gel-caustic-tanney, driscose type	166R 2Dr	68SW 2Dia	14,934-14,960	20 B, 900 MCF, $^{1}/_{16}$", 175#	WC. Discovered new field.
18,629 8,156	S. W. Richardson Walker #1	Richardson & Bass	Gwinville Jefferson Davis	6–27–55 5–21–54	Oil emulsion 6500-15,900'; lime-base to 16,500', LP & OE to TD	209 total	73C	8,150-8'156	4 B, 55.5°-895 MCF, 1400#	WC. Discovered new gas field. Shut-in.
					NEW MEXICO					
15,120 15,025	Continental Oil Belle Lakes Unit #1-A		San Simon Sink, Lea	4–27–55 6–19–54					15,530 MCF open	WC. Discovered new gas field.
					OKLAHOMA					
15,310 Testing	British-American Harrison #2	Big Chief Drilling Co.	Knox Grady							WC. Expect new field. Will be deepest production in Oklahoma.
					TEXAS					
15,002 D & A	Phillips Pet., Houston Farms Dev. #1-Y	Company rig	Chocolate Bayou, Brazoria	4–25–55 1– 2–55	17.2-55-3.4 at TD. Low pH, low solids	65R				FW.
15,294 S. down	John W. Mecom Boyd et al		Wildcat Liberty							WC.
15,500 D & A	Texas Co., Fort Bend Oil-Houston Farms Dev. #2		Chocolate Bayou, Brazoria	5–12–55 12–26–54						WC.
15,819 D & A	Magnolia Pet. J. J. Le Tulle #1	Company rig	Wildcat Matagorda	2–22–55 11– 2–54						WC.
15,833 Temp A	Magnolia Pet. Janie Hawkins #1		Sargent Matagorda	11–24–55 3–30–55			21SW			WC. Had fishing jobs and lost circulation.
16,087 12,714	Stanolind O & G Mary C. Fall #1	Prince Drilling Co.	Sanborn Matagorda	3–12–55 3–20–54	Lime-base oil emulsion 18# max.	69 total	2Dia 10SW	12,702-12,714	2000 MCF, $^{16}/_{64}$", 2665#	FW. Extend field in Frio sand. Drilled in 116 days.
16,212 D & A	Stanolind O & G Houston Farms Dev. #1-D	Company rig	Halls Bayou Brazoria	4–22–55 10–24–54	Lime-base oil emulsion 17.6# max.					WC.
17,001 D & A	Magnolia Pet. Le Tulle #1	Company rig	Wildcat Matagorda	2– 7–55 7–16–54						WC.
18,609 D & A	Gulf Oil, P. G. Worthrup et al #1	Parker Drilling Co.	Wildcat Reeves	12–18–54 1–32–52	Chem. mud 9.0 to 13.8#	359R 7core	23C 23DS			WC. Well temp. aban. 5-15-53. Deepening began 5-30-54. Time to drill, core, test, fish, etc., 508 days.
18,708 D & A	Gulf Oil-Hunt Oil Elsinore Rlty #47	Penrod Drilling Co.	Wildcat Pecos	1–29–55 4–22–54	Chem. mud 8.8 to 10.3#					WC.
19,060 5,115	Magnolia Pet. W. Branch "A" 417	Company rig	Wildcat Jackson	11– 8–55 4– 6–55				4,539-4,551 5,105-5,115	9600 MCF 53 B, $^{5}/_{64}$"	WC. New field. Dual completion in Discorbis, gas sand, and Greta, deeper oil sand.

ana. It drilled Placid Oil's LL&E Unit 13 No. 6, to 15,177 ft in 37 days.

Louisiana wells are most quickly drilled but there have been some that took more than a year. California wells have been drilled in 61 to 516 days and Texas wells in 90 to 682 days. Wildcats in other states have taken even more drilling time.

Drilling Bits

For the first time, average number of bits used on deep wells during the year went below 100. Average per well was 85 bits in 1955.

Possibly this is due a lot to the fact that Louisiana's deep ones have a bigger proportion in the total this year and Louisiana wells use by far the fewest bits. Deep wells have been drilled in Louisiana with only 39 bits.

The new jet bits will also have some influence on the number used in deep drilling. They undoubtedly have something to do with the cut in time also. It may require a full day to make a round-trip on a bit change for one of these deep wells. Drilling time can be shortened considerably by longer service bits.

Mud Costs

Although drilling time and number of drilling bits are decreasing, use of mud and its cost is going the other direction. Many of the wells, with high pressures and high temperatures at great depths could not be drilled today except for the advance in mud engineering and chemistry.

The average cost rises, too, when a few wells require huge quantities of drilling mud and run the cost up to $350,000 to $400,000 for mud only.

Operators and Contractors

An amazing total of 47 individuals or firms have drilled one or more wells below 15,000 ft. Of these, 13 new deep drilling operators were added in 1955.

This does not consider the many partnerships and groups that are concerned with deep wells. Only one operator or firm was listed for each well.

Shell and Texas Company are the only two companies with 30 or more wells at these depths but 10 or more each have been drilled by Phillips, Superior, Richardson and Bass, Humble, Gulf, Magnolia, Stanolind, and Standard Oil of California. Only Texas Company drilled more than 10 in 1955 alone.

Richardson and Bass are the outstanding individual deep well drillers. (Table 6). S. D. Richardson and Perry Bass have drilled 15 wells deeper than 15,000. They are also the operators of the deepest hole in the world — the Louisiana well bottomed at 22,570 ft. These two have been extremely fortunate, also, in completing almost half as producers. Seven out of 15 of their deep wells are producers.

A large number of contractors have drilled the deep wells. This list (Table 7) certainly does not include all the contractors whose tools can drill below 15,000 ft, but the 41 contractors here are an impressive list.

A number of the larger companies use one or more of their own rigs for deep drilling in addition to the long list of contractors with heavy rigs.

The advantages of a large number of well equipped contracting companies can be better appreciated after learning of Russia's deep drilling problems (next article).

Trend Will Continue

Prospects in 1956 are for twice as many super-deep wells as last year. Plans of oil companies that drilled deep wells this year indicate that the number will run about 160 wells this year at a cost of around $100 million invested in wells below 15,000 ft. ★ ★

TABLE 6. OPERATORS OF WELLS DRILLED BELOW 15,000 FT.

Company	Wells drilled before 1955	Wells drilled in 1955	Producers*	Total
Abercrombie, J. S.	1	0	1	1
Brazos Oil & Gas Co.	1	0	1	1
British American	0	1	1	1
Cities Production	0	1	1	1
Continental Oil Co.	3	2	5	5
Denver Product & Ref.	1	0	1	1
Flaitz, J. M.	0	1	0	1
General Petroleum	0	2	0	2
Gulf Oil Corp.	12	1	4	13
Hawkins, H. L.	0	1	0	1
Houston Oil	0	1	0	1
Humble Oil & Ref.	11	4	10	15
Hunt Oil Co.	0	1	0	1
LaGloria Corp.	1	0	1	1
Lamson, Bennett Cole	0	1	0	1
Lion Oil Co.	1	0	0	1
Little Nick Oil Co.	1	0	0	1
Lloyd Corp.	1	1	0	2
Magnolia Pet. Co.	8	4	1	12
Mayfield, M. L.	0	1	1	1
Mecom, John W.	4	3	3	7
Mountain Fuel Supply.	1	0	1	1
Ohio Oil Co.	1	0	0	1
Owen, J. P.	0	1	0	1
Pan American Prod.	2	1	2	3
Pacific Western	1	0	0	1
Pasotex Petroleum	1	0	0	1
Phillips Petroleum	16	1	6	17
Placid Oil Co.	1	2	2	3
Pray, Max	0	1	0	1
Pure Oil Co.	3	1	2	4
Quintana	1	0	0	1
Richardson & Bass	11	4	7	15
Richfield Oil	1	0	1	1
Shell Oil Co.	26	9	28	35
Standard of Calif.	5	5	2	10
Standard of Texas	1	0	0	1
Stanolind Oil & Gas	5	5	4	10
Sun Oil Co.	2	5	3	7
Superior Oil Co.	12	4	8	16
Texas Company	25	12	22	39
Texas Gulf	0	1	0	1
Tide Water Associated.	1	1	2	2
Union of Calif.	1	0	1	1
Union Oil & Gas of La.	0	1	1	1
Union Producing Co.	1	1	2	2
Vasen, George	1	0	0	1
TOTAL	166	80	124	246

*Producers mean those which were completed as producers whether or not they are producing at present.

TABLE 7. DRILLING CONTRACTORS ON WELLS BELOW 15,000 FT

Bell & Burden, Inc.
Los Angeles, Calif.

Big Chief Drilling Co.
Oklahoma City, Okla.

Brinkerhoff Drilling Co.
Denver, Colo.

Lyle Cashion, Inc.
Jackson, Miss.

Crescent Drilling Co.
Monroe, La.

Delta Drilling Co.
Tyler, Texas

Delta Gulf Drilling Co.
Tyler, Texas

Dillard-Waltermire, Inc.
Wichita Falls, Texas

Dixie Drilling Co., Inc.
Dallas, Texas

Drilling & Exploration, Inc.
Los Angeles, Calif.

Harry L. Edwards Drilling Co.
Houston, Texas

Gilger Drilling Co., Ltd.
Houston, Texas

C. G. Glasscock Drilling Co.
Corpus Christi, Texas

Gracey-Hellums Corp.
Houston, Texas

Gulf Coast Drilling Co.
New Orleans, La.

Hilburn Drilling Co.
Dallas, Texas

Howell & Howell
Dallas, Texas

Kerr-McGee
Oklahoma City, Okla.

K. L. Kellogg Drilling Co.
Compton, Calif.

Loffland Brothers Co.
Tulsa, Okla.

Noble Drilling Corp.
Tulsa, Okla.

Offshore Drilling Co.
Baton Rouge, La.

Olson Drilling Co.
Midland, Texas

Owen Drilling Co.
Overton, Texas

Parker Drilling Co.
Tulsa, Okla.

Penrod Drilling Co.
Shreveport, La.

Thomas P. Pike Drilling Co.
Los Angeles, Calif.

Prince Drilling Co., Inc.
Houston, Texas

Richardson & Bass
Fort Worth, Texas

Rocky Mountain Drilling Co.
Los Angeles, Calif.

Rowan Drilling Co., Inc.
Fort Worth, Texas

Southeastern Drilling Corp.
Dallas, Texas

Steen Drilling Co.
Houston, Texas

Sun Drilling Co.
Los Angeles, Calif.

Trinity Drilling Co.
Dallas, Texas

Tri-State Drilling Co.
Laurel, Miss.

C. B. Webster Drilling Co.
Houston, Texas

Western Service Drilling Co.
Longview, Texas

Wheless Drilling Co.
Shreveport, La.

Marshall R. Young
Fort Worth, Texas

Zephyr Drilling Corp.
Tulsa, Okla.

EXCLUSIVE

Average drilling time of holes below 11,500 ft is more than 300 days, *Pravda* reports—Sometimes years elapse before deep producers are completed

Deep Wells in RUSSIA Find NEW OIL

Charles L. Adams

RUSSIA has demanded a sharp increase in deep drilling in Azerbaijan, where oil output, except in the offshore Caspian fields, has shown definite signs of decline in recent years.

The Soviet press reports that studies now prove it is more profitable to drill deep wells (over 3500 meters—or 11,483 ft) in Azerbaijan because of their high yield and better quality of oil. It charges, however, that the Azerbaijan Ministry of the Oil Industry is failing to make use of its deep drilling opportunities.

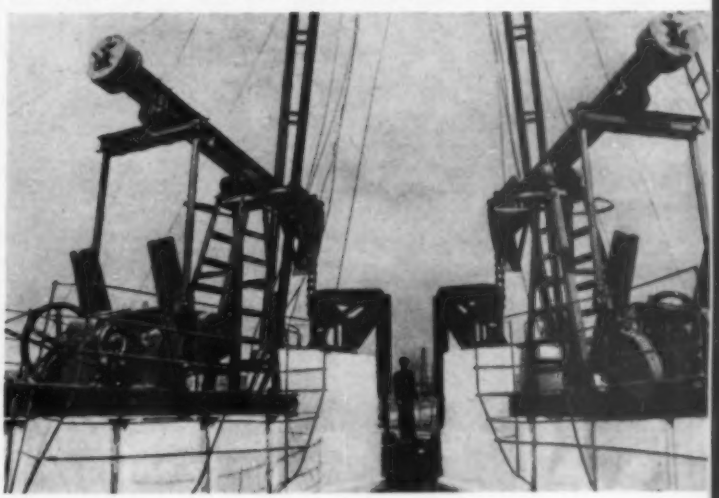
According to the newspaper Pravda, deep drilling in Azerbaijan began (near Gousany) in 1941, when a well reaching a depth of 3904 meters (12,808 ft) flowed 1100 bbl of oil in 24 hr. In June, 1955, a well at the southeast end of the Apsheron peninsula was drilled to 15,787 ft.

Wells more than 11,500 ft deep are now being drilled at several of Azerbaijan's fields. About 50 such wells have been drilled at Baku alone during the past 14 years.

This deep drilling activity, Pravda continued, is being made possible

The UZTM model, one of the latest Russian drilling rigs, is being used at this derrick to drive a prospecting borehole to a depth of 17,000 ft. Soviet oil industry officials claim that the rig "assures high drilling speed and no divergence from the direction taken."

Surface machinery of a Russian multiple well, where, according to the Soviet press, oil is extracted from several strata at the same time.



Oil derricks at the Baku fields in Azerbaijan.

by steadily improving machinery and technique.

Turbodrills on Deep Holes

"Our oil workers now have a 174-ft* derrick with a lifting capacity of 300 tons and complex drilling rig. Turbodrills are used at depths of up to 13,100 ft. Regulating and measuring apparatus makes it possible to check on and control production processes. A radioactive method of studying wells is being used.

"New equipment and know-how now make possible the tapping of previously inaccessible horizons. It has been scientifically proved and confirmed in practice that huge quantities of high-quality oil can be found at great depths in Azerbaijan.

"For example, a ninth field — the Ordzhonikidze field — has been established at Gousany on the basis of deep drilling. Almost 4,500,000 bbl of oil with a large percentage of light fractions have already been obtained from 14 wells.

"Well No. 1815, which went into operation at the Ordzhonikidze field recently, yields about 750 bbl of liquid fuel daily. One of the wells at Lok-Batan yields 21,200,000 cu ft of gas and 375 bbl of light oil daily."

The Russian newspaper admitted that even the most expert deep exploration in Azerbaijan "is not always crowned with success." On the other hand, it asserted that faster, more efficient and cheaper drilling would be possible if the Azerbaijan Ministry of the Oil Industry paid more attention to these problems.

"Exploration is always accompanied by the risk of materials and funds. Unforeseen obstacles frequently arise. But this only focuses attention on the need for a more attentive and creative attitude toward deep well drilling.

Half Deep Wells Dry

"Insufficient thought in the selection of areas to be drilled and in the allocation of materials and manpower among many fields, plus the lack of critical analysis of local data, mean that geological tasks remain unsolved and plans for test drilling are not met. Half of the deep wells drilled on land have proved to be dry holes.

"Organizational confusion between the oil ministry and the supply organizations also hampers the drillers. Work on the 15 deep wells now being drilled in Azerbaijan is being delayed by forced stoppages resulting from inadequate supplies.

"Russian equipment has been used successfully in drilling under difficult conditions. The only complaint is that our equipment is too cumbersome. It is difficult to transport and assemble a drilling rig weighing almost 100 tons.

"We achieve durability in our drilling pipe not by improving its quality but by making it thicker. This is unprofitable to the government and creates additional drilling difficulties.

Drilling Time 300 Days

"The slow increase in drilling speed also is cause for serious alarm. While individual advanced brigades have high indexes, the average drilling time for deep wells is still more than 300 days. Yet it is known that the longer the drilling lasts, the more accidents and complications there are, and the higher the costs run.

"Wells No. 1517 and No. 1400, both of approximately the same depth, were drilled in the same part of the Gousany area. However, Well No. 1517 was drilledin 8 months at an average speed of 1586 ft per month, while Well No. 1400 took more than 3 years to drill atan average speed of 273 ft per month. The second well cost almost twice as much as the first.

Completion Slow

"Possibly the greatest obstacle to putting deep wells into operation is the time lag between testing work and actual utilization of the wells. As a rule, several months, and sometimes even years, elapse between the time wells are drilled and the time they are put in full operation.

"In the Turkyan area, for example, of 8 deep wells drilled a long while ago, only two are in operation. Well No. 1211 has been idle since 1948, and two others have not been operated since drilling was completed in 1951.

"This situation is due in large measure to inefficiency and lack of coordination in the work of local organizations and to overcautiousness on their part. No one is willing to take responsibility for designating the most productive horizons.

"Technical facilities also are not set up promptly. Such delays are costing the government very dearly.

"There is general carelessness with regard to problems of economy at every turn. This, above all, explains the excessively high unit cost of drilling deep wells. But officials of the Azerbaijan Ministry of the Oil Industry show little concern.

"As one administrative chief expressed it: 'Expenses are nothing to worry about. In the long run, the deep wells will pay for themselves'." * *

*Several U. S. manufacturers build 189-ft API derricks.

Progress Report . . .

WORLD'S DEEPEST WELL

Now at 22,570 Feet

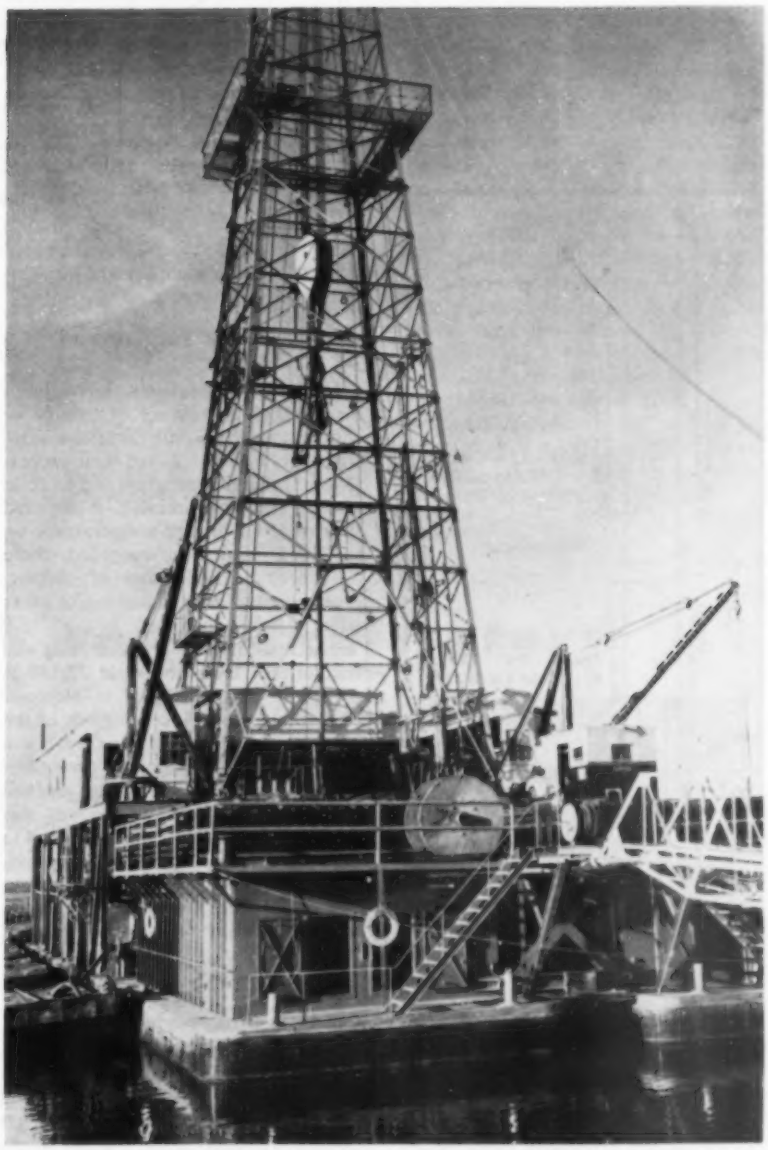
Richardson & Bass wildcat more than 4½ miles down encountered first difficulty; now underway to test bottom sands

ON last report, a 5-in. liner was being run to test deep sands in the Richardson & Bass exploratory well located 35 miles south of New Orleans. Setting many new records, the well was drilled on November 9, 1955, past the 21,482-ft record previously held by Ohio Oil Company. (For progress to record-breaking depth see page B-35 Petroleum Engineer, December, 1955.) Now at 22,570 ft, the first difficulty in the drilling program was encountered when the well attempted to blow out while coming out of the hole. Total depth was 22,559 ft. After the threat was eliminated and the hole conditioned, the well was deepened 11 ft and electric logs obtained on the lower sands.

Now in the eleventh month of drilling, estimates place the total cost of the well in excess of $2,000,000. The wildcat, Humble L. L. & E. State 2414 No. 1-L, is a joint venture of the Richardson & Bass (Louisiana Acc't), Freeport Sulphur Company and John W. Mecom. The well location is in the marshy Lake Washington area of Plaquemines Parish and is 4½ miles southwest of Port Sulphur, Louisiana.

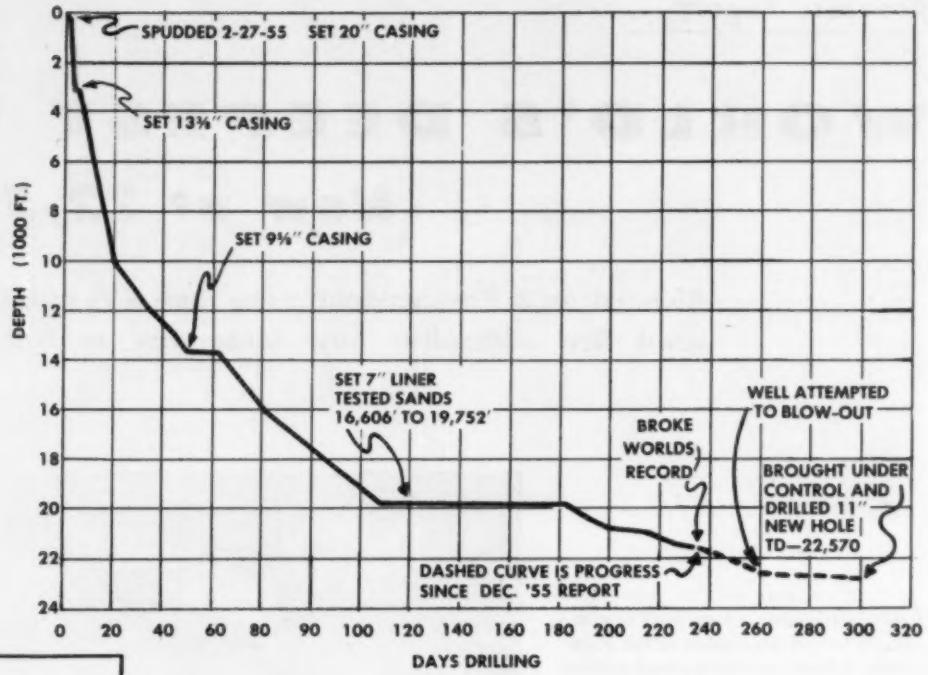
There are indications that a number of excellent shows have been obtained below the 20,500-ft depth. A successful completion in any one of these zones would set a new record in producing depth. The deepest production is presently Richfield Oil Company's well in the North Coles field, California, where production is from perforations from 17,500-17,859 ft.

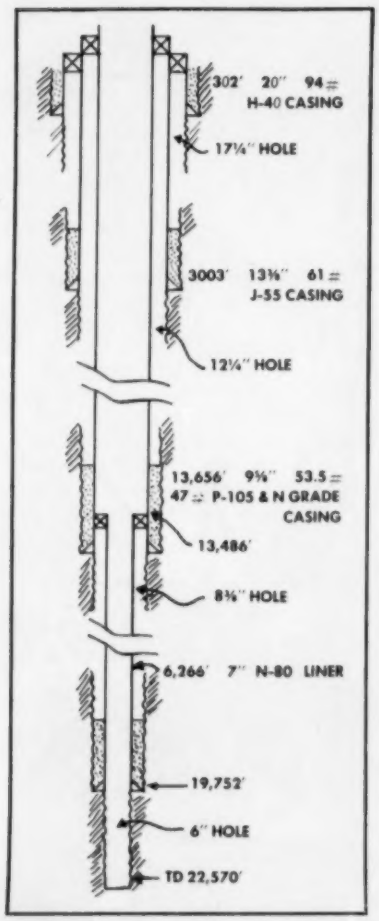
Based on the gas-cutting that has been encountered and the near blow-out with 18.2-lb mud, the bottom-hole pressure on completion may exceed 20,000 psi with the possibility of operating surface pressures in excess of



Richardson & Bass Rig 25 continues operations on the world's deepest well, now in its 11th month at a total depth of 22,570 ft.

Drilling Progress Curve for the Humble LI&E State 2414 No. 1 to total depth. Solid line indicates progress *troleum Engineer*, December, 1955, p. B-35. Dashed line indicates progress since that time.


SPUDDED 2-27-55 SET 20" CASING
SET 13⅜" CASING
SET 9⅝" CASING
SET 7" LINER TESTED SANDS 16,606' TO 19,752'
BROKE WORLDS RECORD
WELL ATTEMPTED TO BLOW-OUT
BROUGHT UNDER CONTROL AND DRILLED 11" NEW HOLE TD—22,570
DASHED CURVE IS PROGRESS SINCE DEC. '55 REPORT
DEPTH (1000 FT.)
DAYS DRILLING
0 20 40 60 80 90 100 120 140 160 180 200 220 240 260 280 300 320
0 2 4 6 8 10 12 14 16 18 20 22 24



Current Status of Deepest Well is shown by this schematic diagram including casing program and total depth.

15,000 psi. This pressure would be considerably greater than any known completions at this time.

First Difficulty Encountered At 22,559 Ft

Drilling operations have been marked by the absence of trouble so common to the South Louisiana area. Operators have attributed their success to a well-planned program and to close control and programming of the mud system. Even though temperatures up to 350 F have been recorded, there have been no indications of sticking, excessive filter cake, sloughing or other adverse hole conditions.

The first difficulty while drilling was encountered December 7 at 22,559 ft when the well attempted to blowout. This occurred while coming out of the hole. Eleven stands of pipe were run back in and the blowout preventers closed. Pressure in the casing reached a high of 2750 psi, and the well was shut in for six days to allow the mud to gel up. Pressure decreased to approximately 1200 psi, and the drill pipe was run in the hole with snubbing equipment. A total of 25 days was required to wash bridges, ream and condition mud back to total depth.

Mud Weight Varied to Control Gas Sands

Lack of trouble in drilling has been the result of close control of the mud properties and the ability to handle gas cutting. The mud in use is a low solids, lime based oil-emulsion mud possessing low water-loss and gel-strength characteristics. Below 15,000 ft, the weight was closely held at 17.8 lb per gallon, 75 sec viscosity and 2.6 cc water loss. At 22,463 ft, severe gas cutting was encountered, and weight was raised to 18.2 lb per gal while maintaining other properties more or less constant. In drilling from this depth to 22,559 ft, the mud weight ran approximately 18 to 18.2 lb per gallon to maintain pressure on the gas sands. Degassing and advanced mud-handling equipment used has enabled the operator to maintain mud weight at 18 to 18.2 lb in spite of gasing conditions. During reaming and conditioning operations, 18.5-lb mud was used to circulate and condition drilling fluid back to bottom. Present weight of mud in well while running liner is reported to be 18.3 lb, with a 2.8 cc water loss.

At tremendous depth, drilling was slowed by long trip times.

Spudded on February 27, 1955, drilling is now in the eleventh month of operations. Casing that has been set in the well includes 20-in., 13⅜-in., 9⅝-in. set at 13,656 ft and a 7-in. liner set at 19,752 ft. Drilling below the liner has been with 6-in. bits.

Drilling rates at these record depths has been a slow average of only about 30 to 35 ft per day. While on bottom, drilling rates have been considerably greater than this, average drilling time has been greatly reduced by the time required to condition mud and round trip pipe. Drilling rates of 555 ft per day were obtained at 10,000 ft, 122 ft per day at 13,656 ft and further reduced to 95 ft per day at 19,782 ft. ★

Unusual flexibility and safety features incorporated in power rig located on three-decked structure

WILDCAT

52 Miles at Sea in 103 Feet of Water

Donald M. Taylor
Editor, Gulf Coast

IT'S an hour-and-a-half helicopter flight or an 8-hour boat ride from the South Louisiana mainland to Block 180 where Salt Dome Production Company is drilling a wildcat for Gulf Oil Corportation. Make the trip either way and you will have an added respect for the oil industry.

The rig is located 52 miles from the nearest land and about 75 airline miles from the nearest settlement which is Grand Cheniere, Louisiana (Population — few). It is in 103 ft of water; and these are records of both offshore distance and water depth.

To visit the rig is quite a feat. You have to drive to one of two jumping off places about 45 miles south of Lake Charles, Louisiana. The roads wander aimlessly through marshes where mosquitoes are so bad part of the time that you have to drive with the windows up. In the winter months these pests have abated, and the chief difficulty stems from the whimsical weather. Three large rivers empty chill waters into this relatively dead corner of the Gulf, and the meterological result is a localized weather which is very difficult to forecast. For instance, the day may be sparkling clear at Grande Cheniere, where the helicopters take off, yet the offshore Gulf may be socked in with a white haze that makes flight impossible. At the same time the water may be so rough that even the crew of the 85-ft boat which services the rig becomes seasick.

This weather, great distance from shore to deep water add considerable blue coloring to the chips which Gulf Oil is gambling on this rank wildcat.

At first glance the drilling rig setup appears similar to dozens of others throughout the offshore Gulf area. Salt Dome Production has a 442-ton substructure sitting on a 6-pile platform (batter on piling is 1:15) with a conventional derrick towering above. Tied to it is Gulf Oil's drilling tender "Pelican", a new tender with its heliport atop the deck house and mud pumps, mud tanks and storage, below decks.

But closer observation reveals that the rig, now drilling its first location, is one of the most carefully designed drilling units ever assembled. The safety features are elaborate; and the instrumentation and controls impress on you that "automation" at least has its foot inside the drilling industry door.

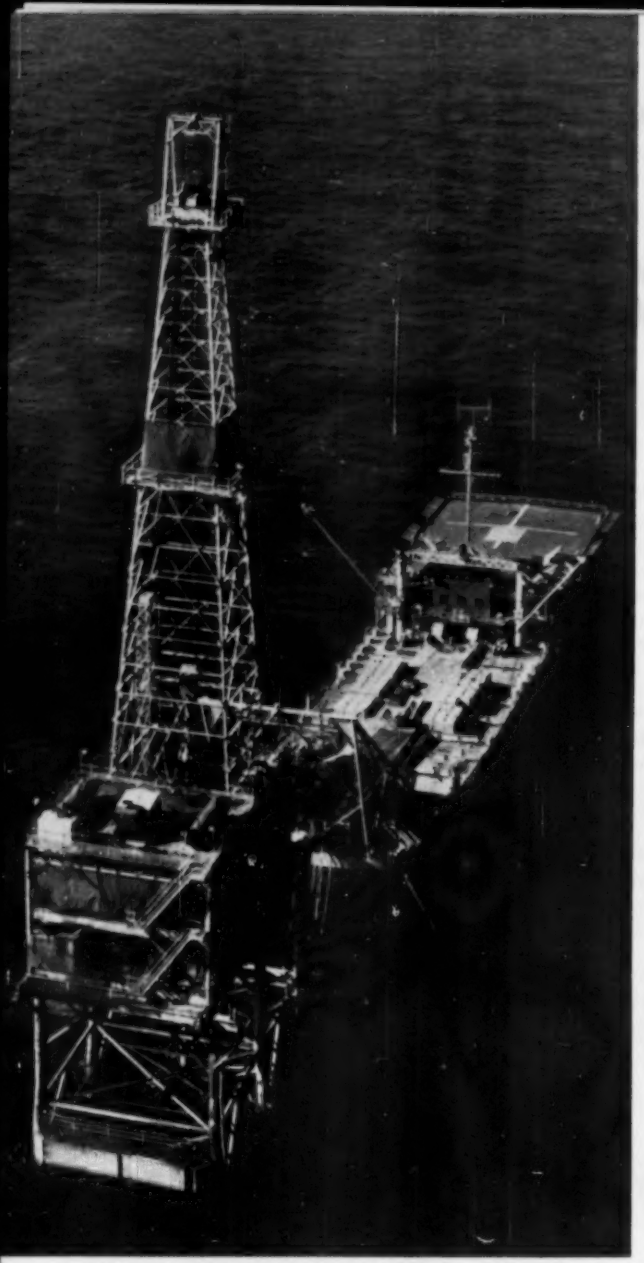
Here, for example, are a few of the remarkable features of the rig:

What it took to get this story

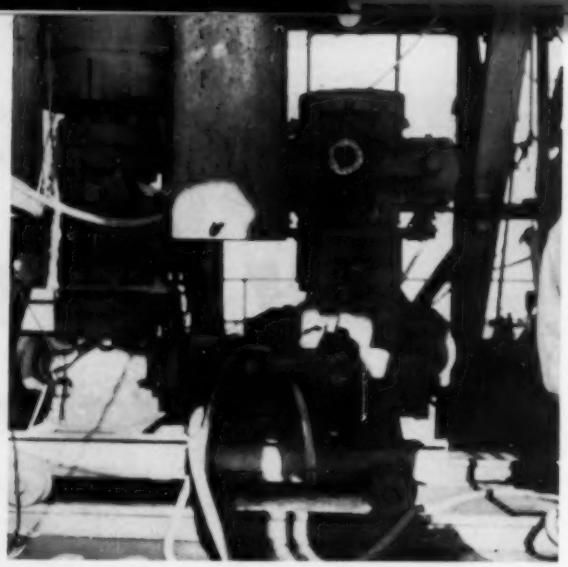
It takes a lot of patience and "arranging" to get a story like this one. In reading the following pages you might ask "What does it take to get the photographs and information?" Don Taylor, PE's able Gulf Coast editor will be the first to tell you it takes patience and a lot of doing. After the necessary arrangements with Salt Dome officials were made, editor Taylor drove to Grand Cheniere, an all-night junket from his Houston headquarters.

It's only a 1½-hr helicopter ride out to the "Pelican," if the weather is clear. It may be beautiful ashore, but due to cold river currents mixing with the warm Gulf stream, a haze sometimes hangs over the structure. One dry run, two flight cancellations and two days later, Don was on the rig. Weight was such a critical factor that Taylor had to leave his flash equipment behind. Here's his story.

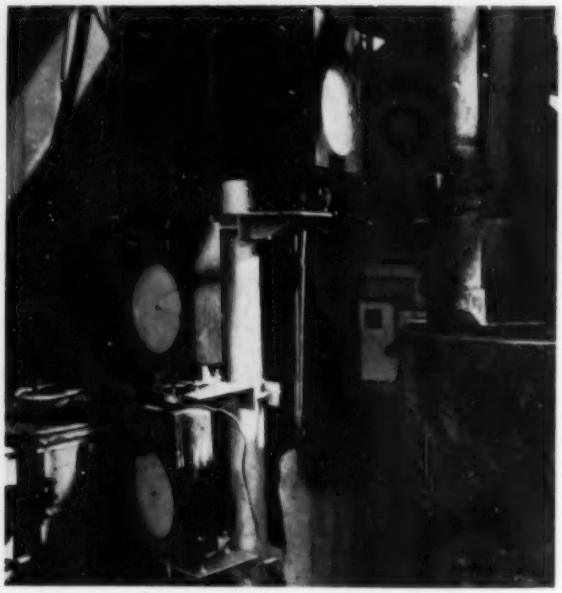
PE's Gulf Coast Editor, Don Taylor at left disembarks on tender's heliport from Petroleum Helicopters Inc.'s Sikorsky S-55, with pilot Owen Guidry.



In Deepest Water Yet and 52 Miles from Shore, Salt Dome Production Company's platform-mounted rig with Gulf Oil's tender "Pelican" is drilling a deep wildcat in the Gulf of Mexico. Main mud pumps, mud tanks, storage hoppers are on the tender. Pumps are operated remotely.



Rail Dolly Saves Money in changing blowout preventers. Mounted on tracks, units simplifies switching from BOP used to drill surface hole.



Mud Tank Level and Mud Weight are recorded on floor. Due to "roll" of "Pelican," special bracing for floats in tanks was necessary.

- It has a $135,000 blowout preventer layout, and the preventers on the well can be operated from the rig floor by hydraulic valves and from two emergency stations by push-buttons.
- The preventer assemblies can be easily and quickly exchanged as their service switches from conductor to surface pipe to protection casing, etc.
- It has a quadruple choke manifold.
- The driller can operate the power pumps on the "Pelican" by remote control. He can set the strokes per minute to any desired rate even though the engines are turning at constant speed. Also he can compound the pumps by a flip of a switch. Thus, the pumps have the flexibility usually attributed to steam power plus the fuel advantages, of diesel powered pumps.
- The rig has an automatic stabbing board, power tubing and casing tongs with automatic slips. It has the world's largest traveling block which weighs 27,000 lb.
- The rig has built-in jacks which can skid it 10 ft in 3 hours. They are actuated by one of the blowout preventer pumps.
- The heavy substructure of the rig is designed for easy loading and unloading for shipment. It comes apart in three sections.
- In addition to mud in the pits,

Newest Innovation in Offshore Drilling is this remote control panel for mud pumps. They may be started, stopped, compounded, and the strokes per minute selected. Salt Dome driller W. R. Jones adjusts coupling control.

Push Button Blowout Preventer Station. Two of these electrically-operated stations enable crew to close any one of three preventers remotely by simply pushing a button. Tool pusher R. J. Boland demonstrates use of controls.

Automatic Stabbing Board folded up against derrick speeds running casing. Travelling block at right is said to be world's largest with a gross weight of 27,000 lb.

the tender stores 730,000 lb of bulk and sack mud, and bulk cement as well.

Of these features, the two most unusual ones from the drilling standpoint are the blowout preventer arrangement and the electro-dynamically coupled pumps. The draw works is powered by three 500-hp engines with torque converter drive. These same engines furnish power for an 8 x 18 mud pump located on the substructure. It is used for emergencies, particularly when the tender must cut loose from the platform during rough weather.

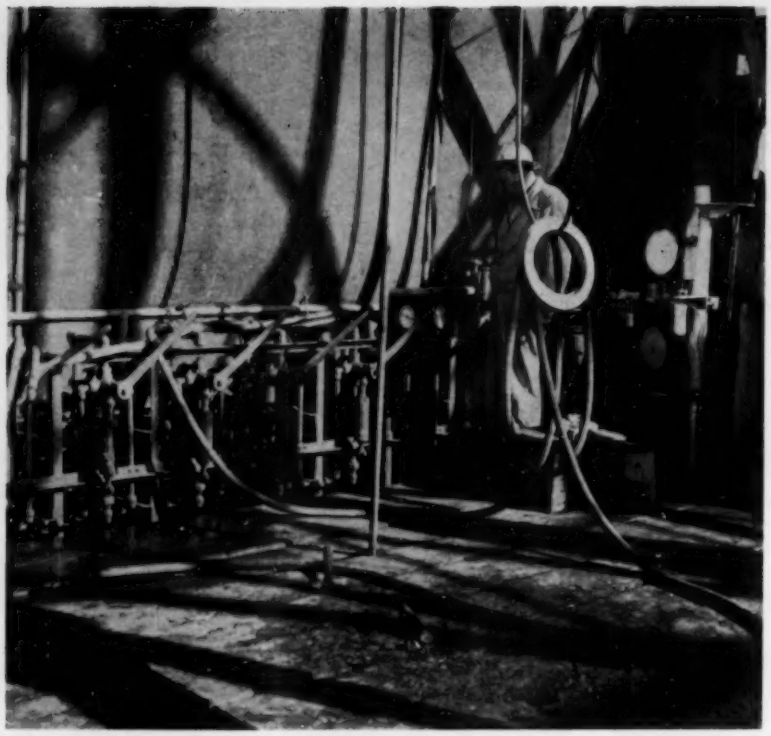
The drill line is 1⅜ in. in diameter and 5000 ft long. To take advantage of this added strength, Salt Dome purchased the world's largest traveling block.

Mud system. On the platform beneath the draw works engines are two small 150-bbl tanks that can be used to continue circulation during emergencies. Ordinarily, they are used as sand traps. Right above them is the degasser and the choke box.

The main mud tanks are below decks on the "Pelican". There are two 500-bbl active pits and one 1200-bbl reserve pit. The cementing equipment, mud storage and mud mixing equipment also are on the tender. In bulk hoppers below decks is storage for 2800 sacks of mud; on deck there are 3000 sacks of bulk mud stored in 50-sack cans and in the ship's hold there are 1500 sacks of mud. In addition, there is storage for the bulk cement.

Pump Speed Independent of Engine Speed

Advantages of steam mud pumps were built into the power pumps along with innovations which make this



Remote BOP Control Station and choke manifold. Gages show pressures in two accumulators. Pusher R. J. Boland of Salt Dome has hand on valve which operates master valve.

pump installation outstanding.

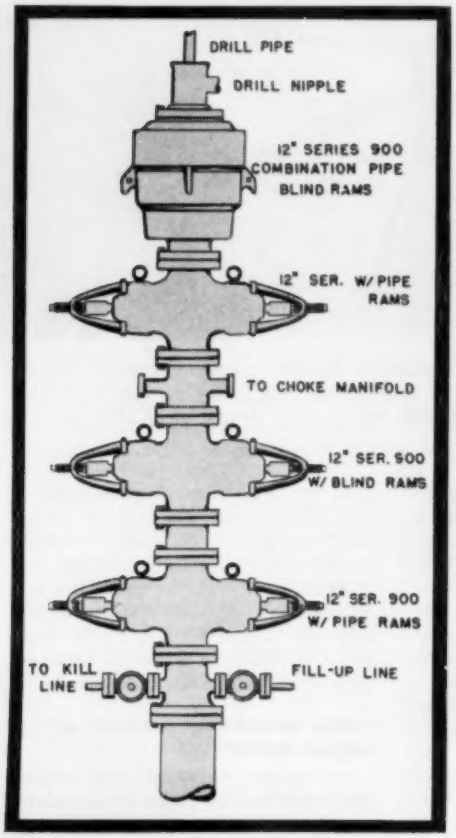
The driller remotely operates the two pumps on the "Pelican", (which are 8 by 18 600 hp units powered by 625 hp engines) from a control board on the rig floor. He can start the pumps, stop them and speed them up and with a flip of a switch he can compound them. More unusual still, he can set the number of pump strokes per minute independently of engine speed, by turning one of the dials on the same control panel!

What makes the latter possible is new electro-dynamic couplings which can be set for any desired slippage, even 100 per cent. For example, the driller can keep the engines running at operating speed and normal horsepower and efficiency, can if desired, set the pumps to make two strokes per minute.

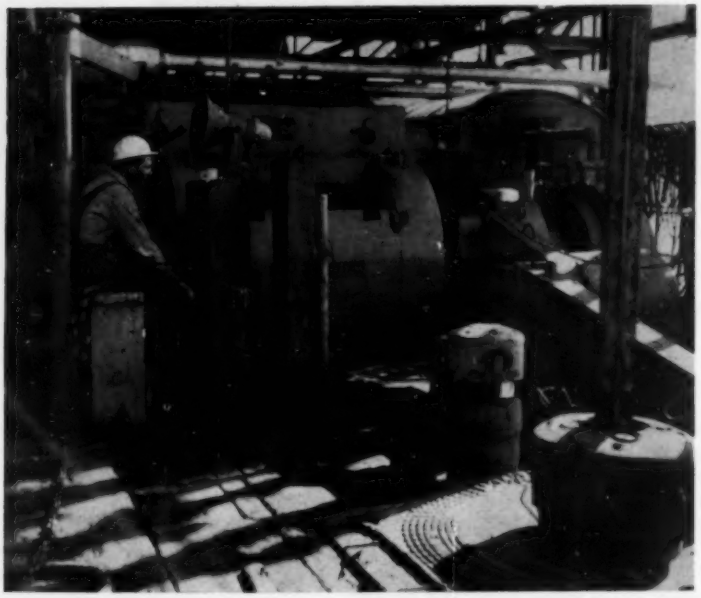
As a safety feature, the remote control arrangement can be nullified from the individual pump to forestall the driller from starting the pumps while they are being serviced.

How Blowout Preventer System Works

The great nemesis of the drilling industry is the well out of control. The threat to the safety of men and equipment from this danger is intensified on offshore locations. For this reason, Salt



Four Unit Blow Out Preventer Hook-up on Salt Dome's big rig drilling for Gulf oil 52 miles from shore.



Nerve Center of Rig is at driller's position. Salt Dome driller W. R. Jones watches gages and controls at the console with 2-way communications on top.

Dome's chief engineer, Sam Lloyd, who designed the rig spared no valid expense in providing the rig with the most fool-proof and adequate blowout preventer system possible.

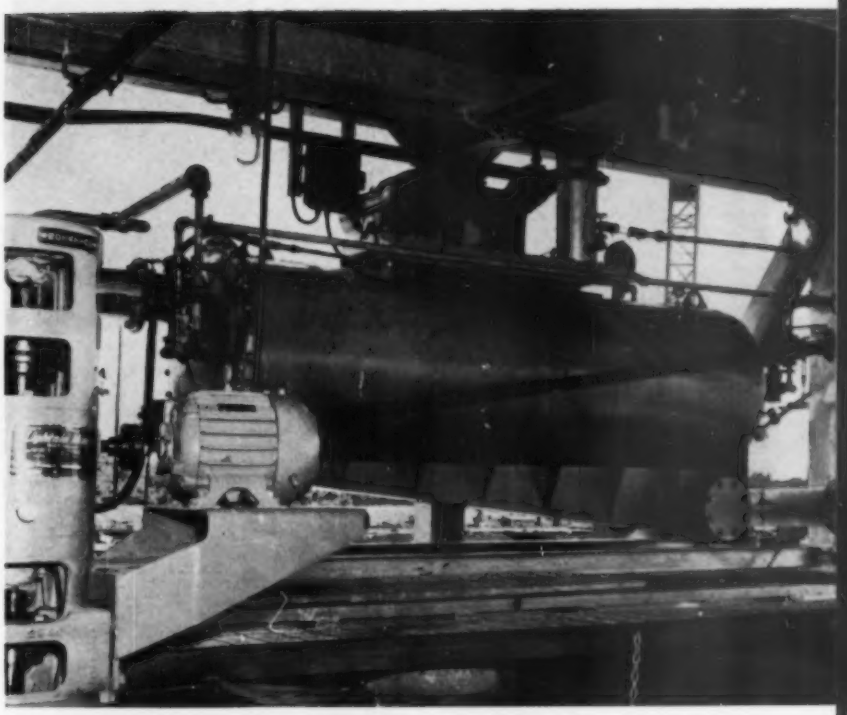
All told, the rig is equipped with 13 preventer units, two closing units, a quadruple choke system and three remote control stations from which the key equipment can be operated. The total cost of this installation ran $135,000!

Once the surface pipe has been set, the preventers are used four at a time as shown in the accompanying illustration. All four of the preventer units along with the two quick-opening valves feeding into the choke manifold system, can be operated hydraulically from the derrick floor.

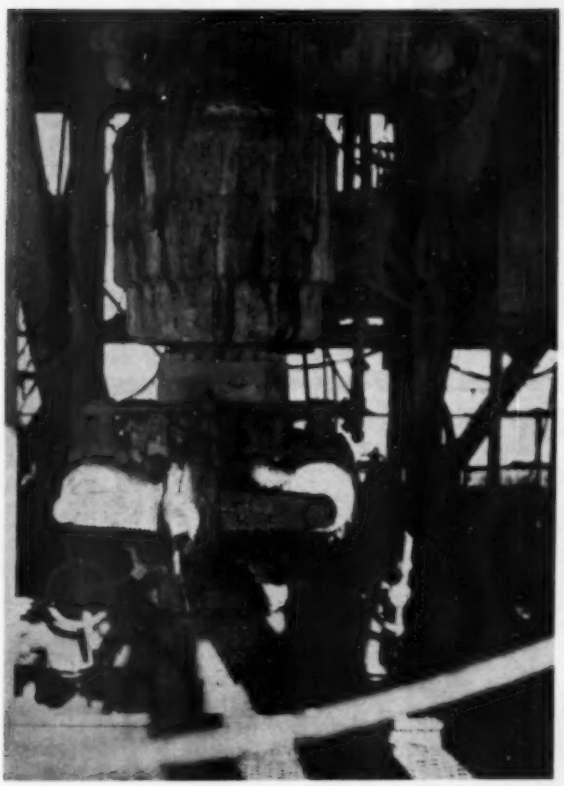
In addition, there are two remote electrically-operated push button stations which operate three of the preventers.

How Preventer System Is Used

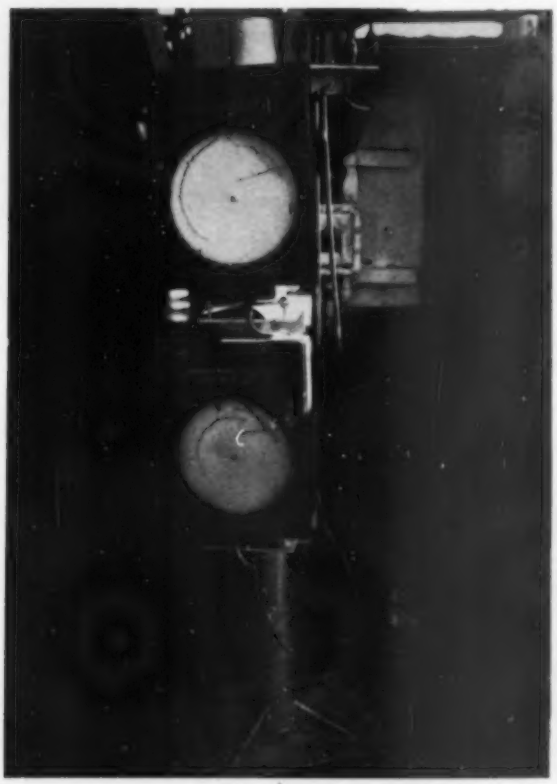
Here is the way this equipment is employed when drilling a wildcat in the Gulf of Mexico. First, a 20-in.



Mud System Equipment includes de-gassing unit in background which has proven successful in removing gas from drilling fluids, and a vertical mud mixer at left mounted above mud pit.

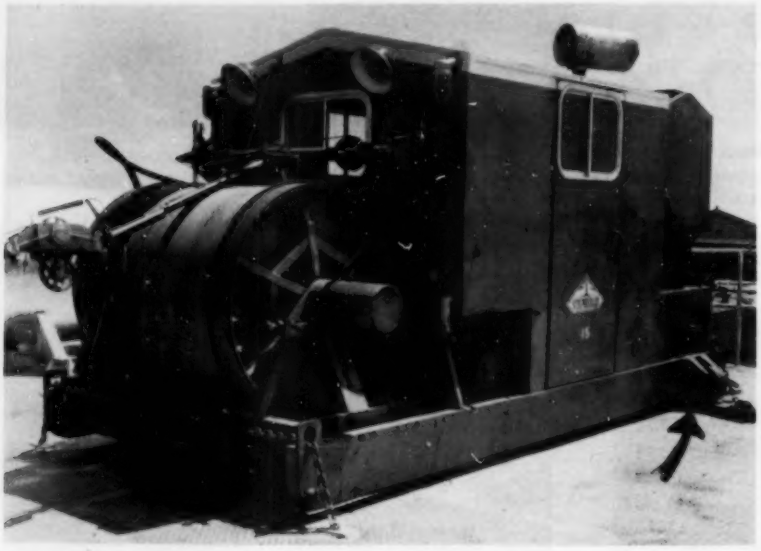


Upper Section of $135,000 BOP Hookup. All four preventers (two top units shown) can be selectively operated by hydraulic remote control station.

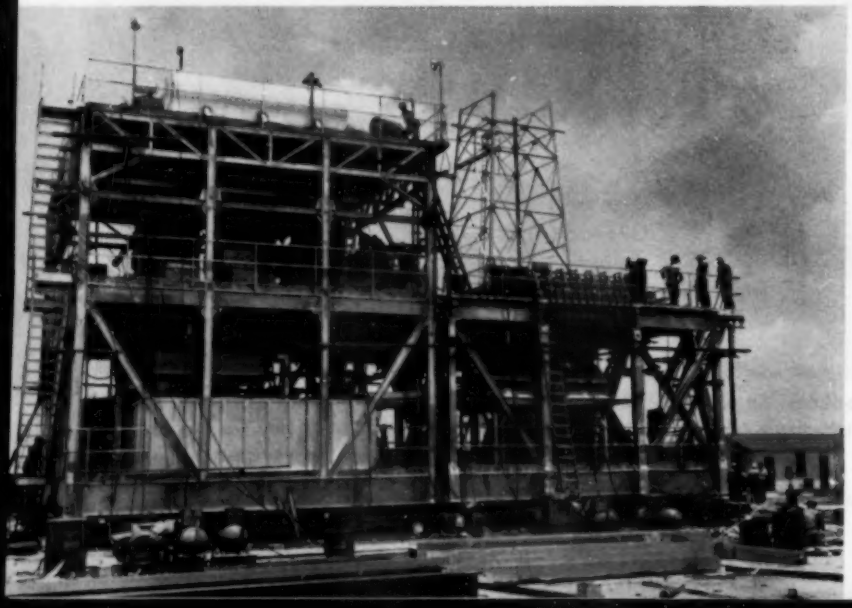


Permanent Records of mud level in tanks and of pressure on stand pipe are made by these two recorders located near the driller.

300,000 Lb Mud in "Cans" on deck of "Pelican." In addition, there are 280,000 lb in bulk hoppers below decks and 1500 sacks in reserve. Two main mud tanks in tender have a capacity of 500 bbl each and a reserve of 1200 bbl capacity.



Portable Logging Unit is chained to upper deck of structure. A variety of logs may be run by this single unit.



442 Tons of Drilling Equipment Ready for Sea. Prefabricated units ashore were barged to location in three sections and placed on structure by cranes. Section "A" is upper deck unit weighing 45 tons; section "B" is engine substructure weighing 210 tons; and section "C" is derrick structure weighing 187 tons. Entire unit sets on 6-pile structure.

preventer is attached to the 30-in. drive pipe (which has been driven some distance below the deepest rig piling.) A 30-in. hub is welded to the top of the 30-in. pipe and quick-coupled with a connection to a 30 by 30-in. adapter spool. This spool has two four-inch outlets which are used as vent lines in the event shallow gas sands are encountered. On top of the adapter is the 20-in. preventer which is also quick-coupled with the special connection. Above this is the 20-in. bell nipple for drilling.

This arrangement gives protection against shallow gas while the 17½-in. pilot hole is drilled for the 600 ft of conductor pipe. Once this hole is down, the preventer is removed and the hole is reamed to 26 in. and the 20-in. conductor pipe is cemented and set.

Next, the 20-in. preventer is coupled onto the 20-in. conductor pipe and surface hole is drilled to about 3000 ft. After the 13⅜-in. surface pipe has been set, and cemented, four preventers arranged as shown in the accompanying illustration, are bolted onto a casinghead. These preventers are changed four at a time as the 9⅝-in. protection string and 5½-in. casing are successsively set.

On the casinghead below the bottom preventer, two 2-in. outlets are hooked to the fill-up line and to the kill line. The spool below the top two preventers is connected into the quadruple choke manifold. And also connected into this choke manifold are the kill line and fill line. Four lines from the four chokes are piped into a horizontal choke box whcih has a baffle arrangement to knock the gas out of the mud.

Speed and Power Built Into Rig

Because of the high overhead connected with operating offshore — especially at this great distance — Salt Dome designed the rig for speed as well as power. In running casing or tubing, the derrick man operates from an auto-

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Figures for 10 Texas wells, where characteristics of mud systems were practically identical with respect to viscosities and weights, show that the use of **DRISCOSE** in a mud with a low concentration of solids helped to increase rate of penetration approximately 25%. Water loss was lower, too . . . 6 to 8 cc with **DRISCOSE** as compared to 10 or 12 cc where **DRISCOSE** was not used. And in addition, wells that mudded up at 10,000 feet with **DRISCOSE** continued to drill just as fast as when they were using clear water . . . no slow-up of penetration due to mudding with **DRISCOSE!** Write for complete information.

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the collar. Pneumatic tubing and casing tongs and power slips are also time savers.

A simple rail dolly speeds blowout preventer changes. On most rigs, when the time comes to change the preventers, they are unbolted, lifted up with the block, and snaked into the substructure of the rig. But on this rig, when the preventers are unbolted, they are lifted and eased onto one of two rail dollies in the substructures and rolled aside.

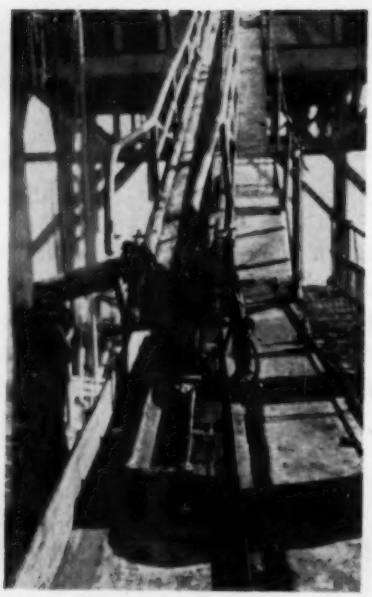
These are but a few of the innovations which have been designed into this rig. There are many more innovations built into this rig than can be told here.

Company Officials Inspect Rig. Left to right: K. F. Hasselmann, president of Salt Dome Production; O. W. Crisman, offshore zone superintendent, Gulf Refining Company; N. C. Simpson, operations manager western hemisphere, Gulf Oil Corporation; R. L. Woodfin, Avondale Marine Ways; L. H. Moore, general manager Houston district, Gulf Oil Corporation; E. D. Brockett, vice president Houston district, Gulf Oil; S. P. Stone, vice president Avondale Marine Ways; Harry Riddle, yard superintendent Avondale; and Sam H. Lloyd, chief engineer of Salt Dome Production who designed the rig.

Unusual Features of Salt Dome's Offshore Rig

Among the many unusual and outstanding features of Salt Dome's giant drilling rig, here are just three that add much to the efficiency and flexibility of the operation.

1. Automatic device for skidding rig on tracks to drill several wells from a single platform. Several reversible skid jacks were incorporated in the design of the structure so it could be moved on the platform to permit drilling a number of wells. These hydraulic jacks are manipulated by control stations equipped with hydraulic valves. Pressure is supplied from the blowout preventer pumps. The control stations are so located that the operator can see how much movement is made and how how far to skid the rig.



2. Greased skid mounted on forward deck of tender supports the walkway which is attached to various piping and control lines. The walkway is swivelled to the sliding element base so that it accommodates movement of the tender with wave action.

3. Portable logging unit is fastened on upper deck and must be turned to line up with the derrick from one well location to another. To simplify this turning, front end of the logging structure was fitted with large heavy-duty casters that roll on tracks welded to the upper deck. The entire unit is chained in position when lined up with the derrick. It is a simple matter to realign the unit when the derrick is skidded.

An optimistic attitude on oil-finding in this country is essential, and there exists numerous possibilities that should be fully explored in view of well-known facts and new and promising developments. For some views on where our new oil is going to come from and how we will find it, an expert tells what . . .

"geologists are talking about . . ."

Dr. A. I. Levorsen
Consulting Geologist
Tulsa, Oklahoma

IF the present and recent petroleum consumption figures of the United States are projected ahead, it is seen that this country will require twice as much oil per year by 1980 as now. The U. S. will then need around 14 or 15, 000,000 bbl of oil per day, or the equivalent of an East Texas pool every year! And in addition, it will need some 15 to 20 trillions cubic feet of gas every year — the equivalent of a Hugoton pool. All of this petroleum is burned up — there is no scrap left to use again, no seed to start a new crop, nor is there any significant amount in above-ground stockpile to be used in a national emergency.

The petroleum industry is different from most other American industries in that its raw material requires a continuous process of discovery, otherwise the industry would collapse in a matter of a few years. The heart of our industry is an adequate supply of crude oil. At present, there is probably enough oil outside the United States to run the world, including the United States, for a long, long time. But, to import our oil needs is to risk our future as a nation, for, as the IPAA emphasizes, "There is no security in foreign oil for the defense of our own borders." We must, therefore, discover, in ever increasing amounts, a continuing supply of oil, preferably within the U.S., but certainly within North America, if we are to survive under present world tensions. The two questions, "Is it there?" and "How can it be discovered?" are basic talk whenever two or more geologists get together.

The principle of oil and gas exploration is quite simple. It can all be stated in six words: "Find a trap — then drill it." As amateur geologists know that the best place to drill is on an anticline or near an up-dip sand pinch-out, and as long as the evidence is clear and evident, there is no particular problem. But as the years roll on, the clear and evident structures are drilled, and in each area it eventually requires the combined efforts of many people, each expert in his particular field, to locate the traps. The principle of exploration remains the same, but the application becames extremely complex — so complex in fact that when traps cannot be found, wells are drilled anyway.

The wildcatter pays for the services of the geologists, the data they use, and the ideas they develop. Sometimes the wildcatter pays and then reaps, other times he just pays and pays and pays; but in any event, he always pays, sooner or later. Maybe it will help ease the pain of paying to know more of some of the new ideas, techniques, and problems that the geologists are talking about.

The Author

Internationally known in petroleum geology, Dr. A. I. Levorsen has always held an optimistic viewpoint on the resourcefulness of the geologist to find new sources of oil. A past president of the Geological Society of America, he is author of the book "Geology of Petroleum" published in 1954. A professor and holder of many degrees, he has had wide experience throughout this country and the world. This thought-provoking discussion was taken from the author's paper by the same title which he presented at the 26th Annual Membership Meeting of the Independent Petroleum Association of America held in St. Louis, Mo., November 1, 1955.

The Geologist and What He Does

Geologists, and especially petroleum geologists, have followed the pattern that has developed in many professions, that is, they have become highly specialized. Their work generally breaks down into two broad categories: (1) gathering data by specialists, who are expert technicians; and (2) integrating data by idea men into geologic prospects worth drilling. The gathering of data includes such work as surface structural mapping, measuring geologic sections, subsurface mapping, examination of well cuttings, well sitting, electric and radio-active log interpretations, and seismic and other geophysical surveys designed to locate favorable structures.

Where the data collected show a trap in the reservoir rock or a favorable reservoir condition, it is a simple matter for the specialized technician to recommend drilling.

Being faced with increased geological complexities, however, an integration of several kinds of data has become more and more often necessary. This requires a broader background of experience and much more creative and deductive ability. Such integrator geologists might be called "generators" because they can take a variety of obscure and miscellaneous data and from it come up with — or generate — a logical drilling prospect. The chief geologist for one of the major companies, employing hundreds of geologists, said that if he could be assured of one generator for every 20 technician geologists he employs, he would be happy — that in practice it takes that many people to supply the geological technical data for

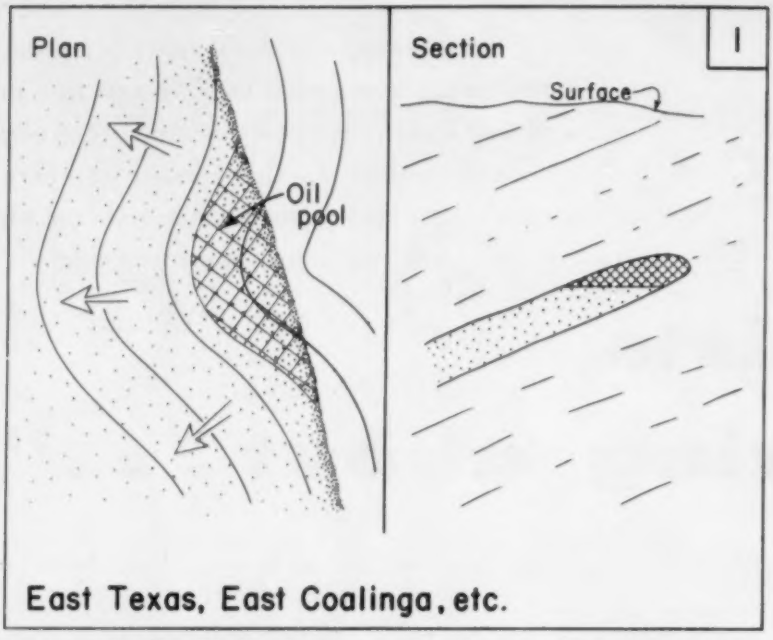


FIG. 1. **Folded, Up-Dip Pinch-out** type of stratigraphic trap is examplified by East Texas and East Coalinga.

one integrator, that is, the data that can be thought through into prospects by one person.

A wellsite geologist should not necessarily be expected to be able to put together surface geology, geologic history, and seismic data into a prospect, any more than a generator-geologist should be expected to be able to go out and know the details of the stratigraphy from his study of the samples. Each has a special place in the scheme of modern exploration, in the same way that doctors and lawyers are also specialists, and each should be used properly.

No revolutionary way. There is no revolutionary new way of finding oil pools. We most probably shall depend chiefly on the proved and tested methods of the past — but with modifications and refinements. The changes are in improved technology, extension of ideas already known, and most of all, hard work.

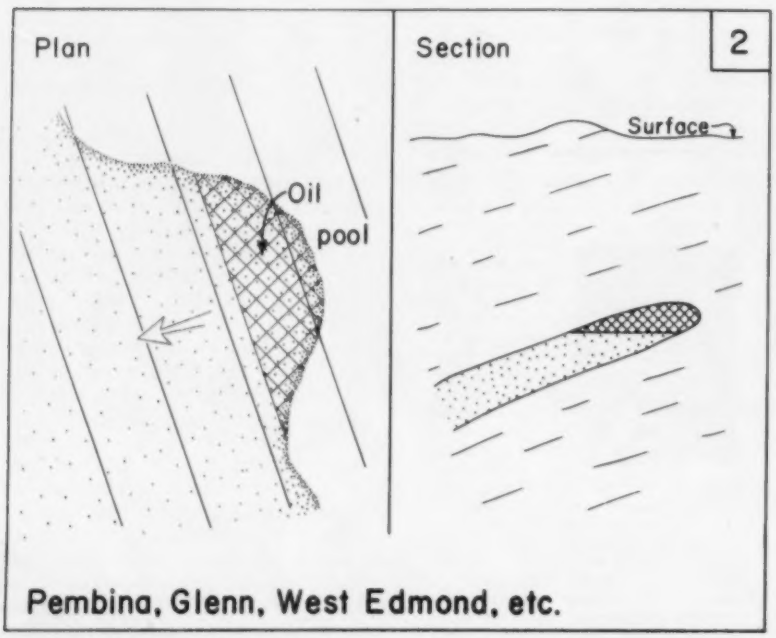


FIG. 2. **Irregular, Up-Dip Pinch-out** type of stratigraphic trap is found in Pembina, Glenn and West Edmond.

Six Basic Thoughts

Among the many new ideas, techniques, and problems that the geologists are talking about, six general subjects are of especial importance in the years immediately ahead. These are: (1) better data for locating structural traps; (2) better data for locating stratigraphic traps; (3) geology of fluids; (4) geologic history; (5) geologic manpower; and (6) complete oil recovery.

Structural data. The first great exploration idea that was developed in the search for petroleum was the anticlinal theory. This gradually expanded into the structural theory to take care of faulted and complex structural traps.

Big advantage in exploration of structural traps is that generally several potential reservoir rocks are defomed into traps on each structure, one above the other, and one wildcat well may explore several potential reservoirs. Structural traps, moreover, are often readily recognized. Most of the industry's effort to find traps has been in trying to locate structural traps.

Because structures have been so actively searched for, they are becoming more and more costly to find. I have asked this same question of many geologists through the years: "If you were assigned the job of finding 100 drillable prospects, what would be the average cost of each?" In 1936-1938, the answer was generally around $25,000 each. Since then it has been going up, and now the average answer is on the order of $100,000 each, including all geological and geophysical work chargeable to finding a prospect, but not including lease and drilling costs. Some even went as high as $200,000 to $300,000 per prospect over a period of several years. If half of this increased cost is inflation, the cost of finding a structural prospect now is still double the cost of 20 years ago. This probably reflects the increased geological difficulties of finding new prospects.

Historically, the search for structural traps in the U. S. has been to map the obvious ones first—those well exposed at the surface, such as the "sheepherder" anticlines of the Rocky Mountains, or the Signal Hill type of fold of California, or some of the salt domes of the Gulf Coast. Then followed the more obscure folds that required more careful and expert geologic mapping, then core drilling for the shallow hidden structures, then subsurface mapping where enough wells had been drilled to make a struc-

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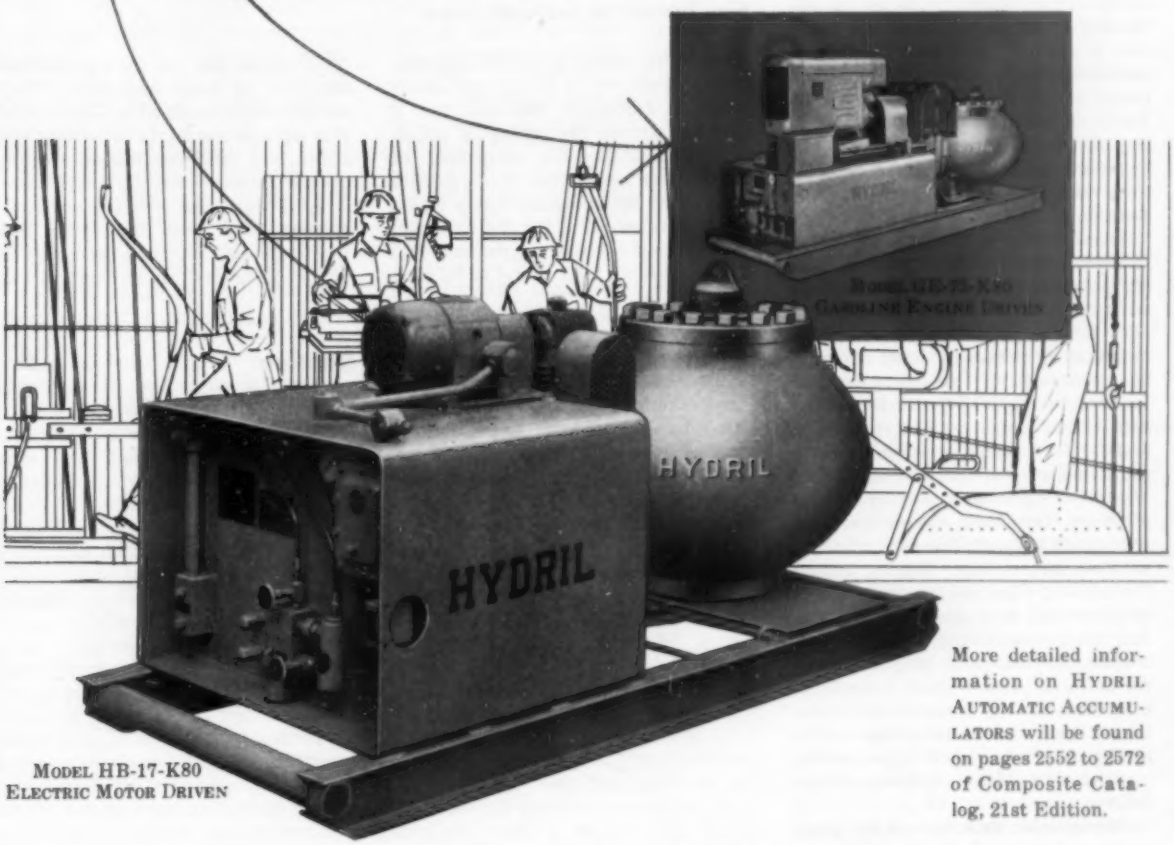

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California: Bakersfield, Los Angeles, Ventura; **Louisiana:** Harvey, New Iberia, New Orleans; **Oklahoma:** Tulsa; **Pennsylvania:** Rochester; **Texas:** Corpus Christi, Dallas, Houston, Midland, Odessa; **Wyoming:** Casper; **Canada:** Calgary, Edmonton.

tural map, then geophysical mapping where no wells or only a few had been drilled. The dominant method of locating structural traps now and during the last 20-25 years is by seismic surveys, and most exploration money is spent for these surveys.

Past experience in structure hunting has tended to be toward more refinement, more accuracy, greater detail, and to require more technical skills. And, it seems to many geologists that this is what is still ahead of us. There are many more structural traps remaining to be found, it is true, but they are generally more obscure than those we have been finding, and most of them can only be found by greater attention to detail. It will require, in fact, a combination of all the geological and geophysical techniques that we know if they are to be located commercially.

There seems to be now as in the past, moreover, enough new ideas and techniques to maintain a good discovery rate in spite of the number of structures that are discovered and drilled each year. Because a structure is obscure or hidden below an unconformity or thrust fault does not mean that it is small, as shown by the experience in the Cuyama Valley of California and in the Ordovician of West Texas. Structures are but one kind of trap in which oil occurs, and that the increased difficulty of finding structures does not necessarily mean an approaching shortage of oil.

Some of the techniques and ideas that geologists believe will aid in finding more structures, include such things as micro-photo-geology, which, as the name suggests, is a microscopic examination of air photos to locate structure by microscopically analyzing obscure features; re-mapping the surface structure of many areas in a more detailed and careful manner, an example being the re-mapping of much of the Rocky Mountain region on 5 to 10-ft contour intervals; improved correlations for subsurface mapping by such methods as continuous velocity logging and by the use of pollen and spores found in well cuttings; new geophone patterns, and the use of magnetic tape for recording seismic data. Magnetic tape, for example, permits much faster mapping, derived data are in a much more usable form, and the same tape can be used over and over again in the laboratory as new ideas of interpretation arise.

Stratigraphic data. One of the great, early geological arguments in the petroleum industry was whether the oil in Pennsylvania and West Virginia was on anticlines or was in sand patches and other irregularities in the sand distribution. Dr. I. C. White, possibly because he was a better salesman, won

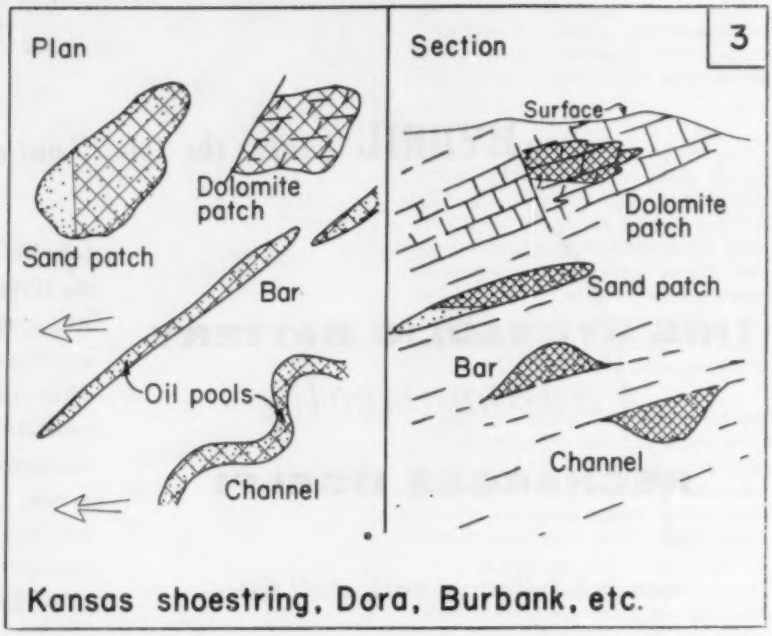

FIG. 3. **One of the Key Problems** is locating sand patches, shoestring sands, bars, channels as indicated above.

out with his statement of the anticlinal theory as the key to oil and gas occurrence. E. DeGolyer once said that if they had known the geological conditions surrounding the occurrence of oil in those areas when the argument was raging, the anticlinal theory would never have evolved, for the examples that were used to support the anticlinal theory were all later found to be sand occurrences, and the folding was incidental or of minor importance. Pools actually were localized in sand patches that were on the flanks or crossed anticlines and sand distribution was the critical feature—not the anticline.

Such traps are now called "stratigraphic traps" and they have been growing in relative importance with the years. As recently as last spring, Paul

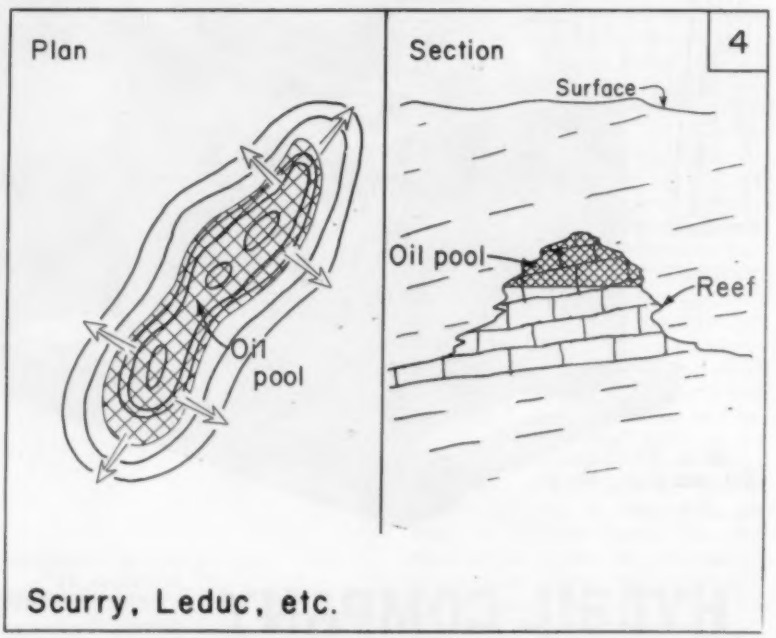

FIG. 4. **Scurry and Leduc** are outstanding examples of limestone reefs that are characterized by little or no local folding or faulting.

Lyons[1], president of the Society of Exploration Geophysicists, reported that: "It is possible to predict . . . that perhaps 75 per cent of the oil ultimately found in the United States will be be stratigraphic."

A recent article by H. P. Woodward[2] summarizes the situation in the Appalachian basin as follows: "Updip pinch-outs of sands, stratigraphic traps subsequent fracture porosity, and the wedging of reservoir and enclosing impermeable strata have been responsible for the largest number of important producing pools in the Appalachian Basin . . . strict adherence to the anticlinal theory of accumulation would be of little value in rediscovering these pools were they now unknown."

If 75 per cent of the oil is stratigraphic, a lot of effort has been wasted, for at least 75 per cent or more of our effort has been in the search for structural traps.

Whereas the chief advantage of the structural trap is that several reservoir formations may form traps in one structure, the stratigraphic trap is a "single shot" prospect. It does have the advantage, however, of generally being an older trap than the structural trap, and therefore has had a longer time to accumulate a pool.

There are several general basic types of stratigraphic traps, all of which contain many important examples of oil pools and are shown in Figs. 1, 2, 3, and 4. One is the folded, up-dip pinchout of a reservoir rock, such as occurs in the East Texas and East Coalinga pools. Another is the irregular, up-dip pinch-out of the reservoir rock on a uniform regional dip, of which the Pembina pool in Canada is the outstanding example. Others are the sandpatch pool, as the Dora and Burbank pools in Oklahoma; the shoestring sand pools, as in Kansas; and the limestone reef pools, as the Scurry pool in Texas. Most are characterized by little or no local folding, faulting, nor anything that can be determined from the surface. They just occur, often completely unexpectedly. Their discovery is one of the key problems of the geologists, geophysicists, and engineers.

If 75 per cent of our oil is to be in traps such as these, it is extremely important to have some logical method of exploring for them. Some of the ideas that geologists are talking about that will do a better job of finding stratigraphic pools include: (1) greater attention to detail, especially in the accuracy and recognition of not only the well samples, but also the fluid samples; (2) careful analysis of the orientation of sand grains in buried sand bars; (3) pattern drilling, that is, holes drilled on regular centers, such as one mile, for example, or even half-mile centers, to test for pools at 1000 to 5000 ft in depth; (4) and more holes down the flanks, and along the plunge of dry anticlines before they are finally condemned. A dry hole at the crest of an anticline or close to a salt dome does not rule out the flanks, where pinchouts, buried faults, or tilted water tables may occur.

Many geologists talk about "distributary sand channels"[3] such as are forming now in the delta of the Mississippi River. Many long ridges of fine-grained sand, built up to 200 ft thick and extending for many miles can be observed in the delta region today; some formed under present conditions and others under past conditions of stream flow[4]. Whereas surface river systems concentrate the flow of the tributaries into a main river channel, the deltaic system distributes or disperses the sediments of the main river into many lesser channels.

Similar buried distributary channels occur in a number of places and many of them contain oil pools. Some of the most striking are in the Seminole region of Oklahoma where the distributary channels of the Booch sand form elongated sand deposits up to 200 ft thick completely encased in shales. Some of the best shallow production of Oklahoma has been in the Booch sand. Knowledge that a sand is a distributary deposit instead of a normal stream deposit, makes a powerful exploration tool.

Dolomites look like limestones and are frequently classed with limestones as reservoir rocks. A dolomite, however, consists of magnesium and calcium carbonate whereas a limestone is chiefly calcium carbonate—and there are all intervening gradations between dolomites and limstones. Reason for the importance of dolomites is that some dolomites are more porous and permeable than either limestones or other dolomites. A great many oil and gas pools are found in the dolomitic part of the reservoir rock, whereas the adjacent limestone is found without any fluids. Thus, in many pools, both in stratigraphic and structural traps, that part of the reservoir rock above the water table is full of oil and gas if the material is dolomite, but dry or of very low productivity if limestone.

The dolomite that in general seems to be the most effective is carried in solutions that come in later along fractures or faults. It replaces the limestone and develops its own permeability and therefore its own supply channel. These same channels later become channels for oil and gas accumulation. The places where dolomite will replace limestone, then, become important places for exploration. One application of this is to re-drill barren anticlines down the flanks, where faulting and fracturing might allow dolomite-bearing solutions to enter the dense limestones and replace them with permeable reservoir rock.

The dolomite problem is an old one in geology and there are still many elements of it that are not understood. New data obtained from the sampling of closely spaced wells give the research geologists an unequalled opportunity of learning how dolomite forms, where it comes from, and especially how to predict where it will occur.

Identification of dolomite and sand patches and of channels such as these is certainly a work for experts. It can only be done successfully when time is given for careful and detailed study of much geological and geophysical data, all of which are expensive. Regional maps are necessary as the frame upon which to hang the detail maps needed to make a wildcat location. Accurate sampling and measurements of formations and careful records of the fluid content are essential. And, along with the careful geologic work, freedom to drill more holes per discovery may be required.

Geology of fluids. Reservoir fluid is a subject that has been suddenly opened up to geologists and it promises to occupy an increasing amount of their attention in the years ahead. It has always been a subject of engineering interest, but the petroleum geologists have only occasionally given it much serious consideration, being content to think mostly about the rocks and very loosely and academically as to the forces that place an oil pool where it is.

Fluids in nature's plumbing system —the gas, oil, and water standing or flowing in the minute, interconnected pore spaces of the rocks—are in an extremely delicate balance. And, what is of even more importance, that their movement and position can be predicted from data that can be obtained from modern drilling techniques or is already available. The pioneer work on this subject was done by Hubbert.[5,6] And, as with any new, fundamental concept, it set off many trains of thought as to its commercial application.

One application of the hydrodynamic concept is to the tilted water-table or displaced oil pool. These occur in areas where there is high topographic relief, as in California and the Rocky Mountains. The pool is found, not at the top of the anticline in its normal position, but down one flank. The pool, in fact, may be displaced completely off the top of the anticline and is not found by conventional structural drilling.

Another application is re-drilling

local anticlines that were dry on top but located close by pools where production has resulted in large pressure sinks or man-made gradients. The Cario pool of Arkansas,[7] is an example of one such discovery where the pressure decline from the neighboring Schuler field had nearly tilted the pool off the top of the Cairo dome, pulling the pool toward the area of decreased pressure.

Careful pressure analysis of reservoir rocks can also aid greatly in predicting nearness to the edge of stratigraphic traps, in determining the proximity to faults or permeability barriers, and in a much better ability to locate pool extensions, off-shoots, and irregularities.

Applications of the delicate balance of fluids in motion in the reservoir rocks are being explored in many areas by many geologists and a body of empirical data is being developed that should be of great value in the years ahead. Three things can be said now. (1) The principle is sound. (2) The application is no better than the data upon which it is based. With correct data to work with, accurate predictions can be made. But, where the pressure measurements are poor, where the correlations doubtful, and where the densities of the fluids are unknown, the predictions also are uncertain. As in subsurface geology, even a small amount of information is helpful, but for accurate predictions a large amount of accurate data is required. (3) Every dry structure, in areas of hydrodynamic reservoir conditions, must be re-examined to see whether the trap has been tested at a location logical on the basis of hydrodynamic factors; not structural alone.

Many geologists are talking about such things as hydrodynamics, pressure head, piezometric surfaces, tilted oil-water contacts, and displaced oil pools. You can expect to hear a lot more about these phenomena in the future, for there are many regions where our past ideas of oil and gas accumulation are being completely revised.

The drill stem test is the key to many of our problems in reservoir fluids and also in stratigraphic traps. The drill stem test of the past has been extremely useful, but it promises to be far more useful in the future.

Three general kinds of information are obtained by the modern drill stem test: (1) kind of fluids present; (2) rate at which they enter the well or the transmissibility of the reservoir rock, and (3) pressure under which they occur in the reservoir. The operator is chiefly interested only in knowing if he has oil or gas, and if so, then some idea of the volume. Generally, data obtained are largely qualitative and used to determine whether or not pipe is set to complete the well as a producer.

This is not enough for the geologist trying to find traps in an area where the fluids are in motion—he must also know the pressure accurately, for from that he can calculate the height to which the water would rise in an open hole, or the pressure-head at the location. When several such pressure measurements are available, he can determine the direction of fluid flow, and from that he can tell where a pool will be located on any structure present in the area.

The geologist attempting to find stratigraphic traps is not happy, either, with modern drill stem tests. Reason is that a drill stem test is not generally made unless there is enough evidence of oil and gas to offer some chance of the well being a producer. Presence of free water in a rock, however, is also important, for it means that it comes from a potential petroleum reservoir rock, and the rate of inflow is a rough measure of its permeability. If somewhere up-dip the same rock carries no free fluids, then in between is a good place to look for a stratigraphic trap. One of the best rules of thumb, in fact, is to move down-dip from a dry well, and up-dip from a wet well. Many prospects can be traced directly to the evidence on fluids, permeability, and pressure obtained from a drill stem test. This is a lot cheaper than the average $100,000 cost per prospect, and for that reason alone, many more complete drill stem tests should be made from which to work.

Geologic history. More and more geological talk is heard about geologic history as a guide to petroleum exploration. Geologic history, as a subject for study, is as old as geology, but the petroleum geologist has such an enormous amount of new data to work with, that geologic history takes on new meaning. Hollis Hedberg[8] recently stated: "Recognize the physical essentials for oil pools, to be sure—source, reservoir, cover, and trap—and search out all available evidence regarding them, but bear in mind that not alone their existence but proper timing in their development may spell out the difference between a rich oil region and one which is relatively barren."

Geologic history is putting together, in chronological order, the various episodes to which the rocks, and especially reservoir rocks, have been subjected. Human history quickly dims with age, and vast differences of interpretation of critical data and of importance attach to every human episode. Is it any wonder, then, that historians of the earth, dealing with millions and hundreds of million years, should disagree?

Studies of geologic history range from regional studies of whole continents down to local areas of a few square miles. Basis of the study is an almost innumerable number of maps of all kinds—sand, clastic ratio, structure, paleogeologic, facies, overlap, sub-crop, pressure, fluid and many others. Objective is to relate the location of oil and gas pools to geologic history.

One of the chief applications of an understanding of the geologic history of a region is that certain episodes, for some reason or another, seem to be associated with the migration of oil and gas and their accumulation into pools. The time interval between the Mississippian and the Pennsylvanian eras, in the Mid-Continent region, for example, was a time of folding and faulting and many traps were formed. The tops of many of them were eroded away, structures became "bald-headed," and the incoming Pennsylvanian seas permitted a deposit, or "cap," of sediments to cover them over. This bit of geologic history seems to have been the setting for many hundreds of oil and gas pools in pre-Pennsylvanian rocks. When one sees this same episode of history over and over result in oil pools, he is encouraged to believe that conditions at that time were more favorable than at other times, and that this sequence of events deserves exploration. Key to our understanding of the occurrence of oil and gas at this, and in many other situations, is the geologic history involved.

Manpower. If we are going to double our production and reserves, we will have to double our geological staffs also. How? And the problem is not only one of quantity, but equally important is quality.

Better geology should result in better exploration, cheaper production costs, and more discovery. When and if the petroleum industry really wants to speed up its discovery, one of the best ways will be to get more and better minds working in exploration. The root of getting better minds is to get better professors in the schools. Not only does the good professor attract the good student, but he also influences the sharper minds to enter his field of study.

Getting better professors comes down largely to paying better salaries and providing better working conditions. As it is now, almost any good professor is constantly offered a higher salary from industry, and he soon feels that his love of teaching is in effect giving a subsidy to education—he helps pay for education by working for less than his commercially minded collegue.

Keeping the good professors on the job is good oil business. It can be done by making outright gifts to schools to

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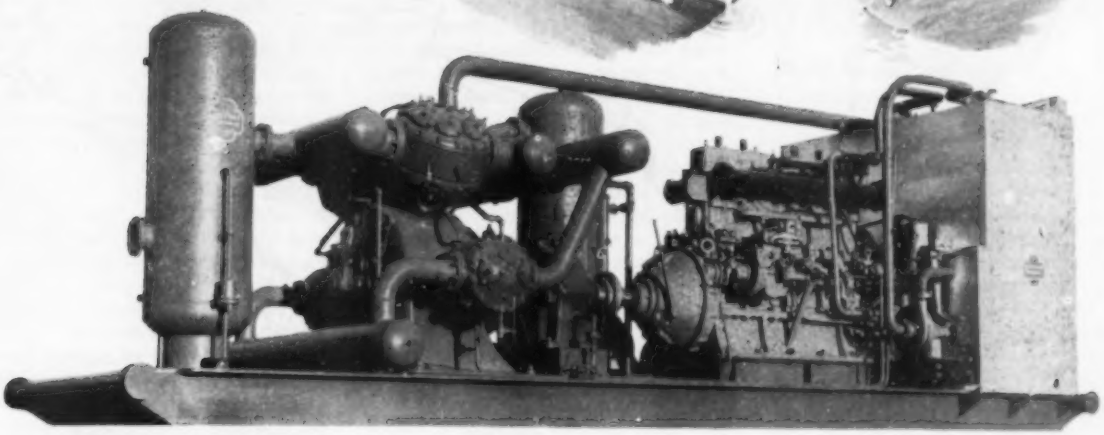

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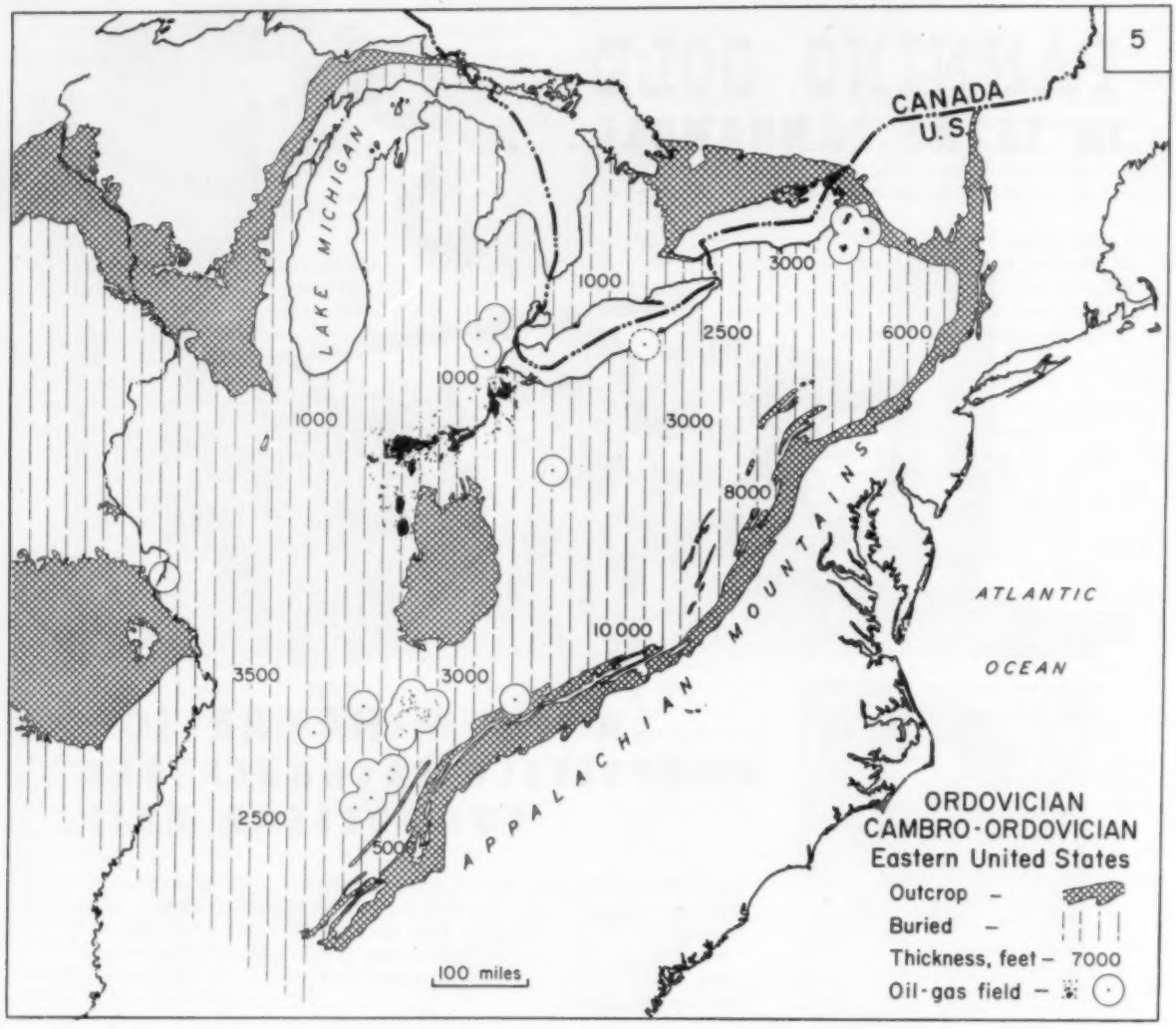

FIG. 5. **Productive Areas** of the Eastern U. S. are indicated in black in this map showing distribution of Ordovician and Cambro-Ordovician formations.

increase salaries, by endowing chairs in basic fields of study, or by giving summer and consulting employment to aid in the professors' yearly income. Just think what would happen if the petroleum industry woud endow a few schools every year with chairs in such fields as geology, geophysics, physics, chemistry, and engineering so as to attract the best teachers in the world!

Complete recovery. There are possibilities inherent in converting such resources as the "tar" sands, the "oil shales," the coal deposits, and the so-called "non-recoverable" oil into petroleum reserves. All of these are in various stages of development, generally close to being commercial. Of these, probably the most intriguing are the possibilities of still further increasing our recovery of petroleum from pools that have been discovered.

Our petroleum resources are frequently broken down into primary, secondary, and tertiary reserves. Up to a few decades ago, the only recoverable reserves were primary reserves and all the rest were termed non-recoverable. Then secondary recovery or "fluid-injection" methods came in, and took an ever-increasing percentage of the so-called non-recoverable oil and placed it on the market. The steady increase in efficiency of the secondary methods has recently been stated by Paul D. Torrey,[9] "A realistic appraisal of the effect of improved recovery technology might be that sufficient additional oil will be produced by this means during the next 20 years to in large measure supplement the anticipated increased demand."

It has been estimated by a committee of the Interstate Oil Compact Commission that the total amount of oil discovered in the U. S. is in the order of 270 billion barrels.[10] Of this amount, only 88 billion barrels or 32 per cent will ultimately be recovered by all known primary and secondary methods.

The great challenge to the petroleum industry today is to do a better job of recovery on the remaining 182 billion barrels—in fact to approach complete recovery. While we are shooting at the future, let's aim high. It is basically a job for the research teams—those "Cadillac" thinkers that have become an integral part of almost every large company's operation. The methods they have come up with so far are in the direction of heating and burning some of the oil in place and thereby driving out the remaining liquids. Many such teams of research workers are deep in the problem, and many schemes are on the drawing boards.

Starting with the premise that oil moved into a reservoir by some combination of physical, chemical, and geological forces, there is good reason to expect that some other combination of forces is able to remove this same oil. The best chance for a solution lies in a complete and thorough understanding of all of the natural phenomena involved in the reservoir—and this, like so many other operations of the industry, is a job for the experts.

It is inconceivable that some way, both economical and practical, will not be worked out to get more or even all of the remaining oil out of the ground. Think what a recovery of 50 per cent —or even of 10 per cent—of the remaining 182 billion barrels would mean! We have seen over and over again where competition by many people has brought about the solution of countless of the so-called "unsolvable" problems of industry. The recovery of today's "non-recoverable" oil in the ground is no more difficult.

Not to be overlooked in the search for complete recovery is the accidental discovery of the solution. Wasn't it the accidental dumping of water into the Bradford reservoir that showed that water flooding increased recovery and started the whole secondary recovery idea which today accounts for nearly 20 per cent of our production? If everybody in the industry is on the alert, there is certainly a good chance of finding the answer, either by sound, planned scientific methods, or by some fluke discovery that has been overlooked by the heavy thinkers.

Areas That Hold Promise

Sooner or later all ideas and techniques must be reduced to apply to specific areas and geologic conditions. Frequently encountered is a factor that outweighs all other factors—that is, the natural optimism or pessimism of the geologist. Some exhaust all of their ideas quickly and can see no more prospects in a region—they might be said to have a high permeability to pessimism. No matter how gloom-soaked and drilled-up an area becomes, there are always some imaginative geologists who still think prospects are to be found by anyone who will go in and do the necessary work. This generally means assembling vast amounts of fluid, pressure, reservoir, geophysical, and geological data, and making a great many maps and sections; for if enough maps and sections are made, and enough thought put to them, prospects will appear.

Each of the ideas and techniques that have developed in recent years, such as electric log analysis, fracturing, side-wall coring, micrologs, radiation logging, etc., has added its increment of new pools or increased production to each of the old districts. Looking at the U. S., then, it seems certain that discoveries will continue to be made in each of the present regions of production, some by presently known ideas, others by ideas yet to be uncovered. But to double our present production at the end of 20 to 25 years requires many really large discoveries. Some examples of regions that could produce large pools, fields, and provinces, based on what we know now[11] are briefly listed. Others will show up with new ideas, new techniques, and new discoveries — for our situation is dynamic.

1. The stratigraphic trap possibilities of the California basins, of the Rocky Mountain region, around the salt plugs of the Gulf Coast, and of the Appalachian basin are tremendous, and they have been described many times by many geologists. Past drilling has been chiefly confined to the crests of the anticlines. But when we see stratigraphic trap pools like Pembina in Canada and East Texas in the United States, some idea may be gained of what can yet be uncovered by nonstructural drilling.

2. There are literally hundreds of anticlines that have been drilled and found dry or barren on the crests, especially in the Rocky Mountain region. Some undoubtedly will hold pools displaced down their sides or along the plunge. An understanding of the effects of pressure-head gradients and the flow of reservoir water on the location of oil pools in such an environment offers a definite way to discover them.

3. Many regional analyses can be made that suggest areas where new provinces might occur. One, by way of example, and it is east of the Mississippi, is shown in Fig. 5. A dozen others of a similar nature come to mind.

The distribution of the Ordovican and Cambro-Ordovician formations is shown in Fig. 5. Areas that have been productive are shown in black. Most productive areas coincide with dolomitic replacements of the limestone, thereby providing both channels for the accumulation of oil and also reservoir space to hold it.

These Cambro-Ordovician and Ordovician rocks are equivalent to the highly productive Viola Limestone, Simpson sands, and Arbuckle and Ellenburger limestones and dolomites of the Mid-Continent.

Away from the productive areas shown, density of drilling that penetrates the Ordovician is exceedingly low. Experience in the Mid-Continent shows the importance of such unpredictable features as unconformities, old folding, dolomitization, buried faulting, and facies changes in localizing oil pools. Even our present slight knowledge of the Cambro-Ordovician east of the Mississippi River shows that all of these features occur.[12] It seems logical to expect that more drilling will uncover more of these features. It is in the cards, in fact, that this group of rocks might contain a pool the size of the East Texas pool — or an East Texas times ten — or several of them. We will never know unless we drill a lot more wells.

More to Be Learned

There are many things we do not know about petroleum and its accumulation — but we are learning. When we add up all the favorable unexplored rocks, the continual stream of new techniques and exploration ideas, a steady increase in recovery, continued conservation, and all the resources that can be translated into petroleum, there is no more reason to say that we are running out of oil now than there was 10, 20, or 30 years ago. There would be danger, though, if we were to run out of ideas, techniques, and trained men for finding it. We have as many and as good ideas and techniques in sight and coming over the horizon now as ever before. For these reasons, there is no cause for alarm due to any expected shortage of petroleum supply in the forseeable future in the U. S., certainly none that an increase in incentive will not cure.

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C. R. Graham
Field Editor

THE year 1955 was a "paradox of progress" for the drilling contractor. Although more rigs were kept running and drilling more hole than ever before, the contract driller received far less for his services, paid more for his equipment and other expense; his foot-per-minute rate of bit penetration appears to have reached its optimum.

As a whole, the oil and gas industry set new marks in every category. Oil companies paid more and higher dividends than in the past; profits in drilling shrank. These profits were figured in fractional percentages. Not long ago, Arthur C. Young made a survey of some 23 drilling contractor companies operating from one to 10 rigs each. Of the total number, four showed no profit. The remainder showed profits between 1.85 and 3.0 per cent return on investment. Profits have been smaller since these figures were compiled.

Cause for this situation stems from the contractor's undesirable position as the only flexible cost among the many rigid expenses incurred in drilling and completing an oil well. Total cost per foot, as estimated by the American Association of Oilwell Drilling Contractors, rose in 1955 to $13.50. This amount is 17 per cent higher than in 1954. Yet the contract price per foot decreased from $5.10 in 1954 to $4.90 in 1955. Such figures, considering lack of any significant increase in the price of crude in the past two years, points to further reduction of profits for the producer — even with the supposition that the contract footage price will remain the same. The footage price, incidentally, has decreased for the last three consecutive years. The producer has also been pressed by depleting reserves; with less success in wildcat operations coupled with incentive-stifling federal regulations in the field of natural gas.

According to statistics, percentage increases included in the total cost per foot, range from 2 to 20 per cent higher in the past year. Since 1941, the AAODC reports, these costs have increased on the average of 200 per cent. In this 15-year period, labor costs have increased 202 per cent; equipment costs have risen 195 per cent and miscellaneous costs have upped 194 per cent. Expense to the drilling contractor for the actual drilling is the only portion that recorded a decrease.

While much is to be said for the increased operating and equipment expense and a static crude price with which the producer must contend — with the drilling contractor caught in the middle of the squeeze — much of the fault for an unstable footage price rests on practices of the drilling contractor himself.

Contractors have found it necessary to cut prices for several reasons, due to intense competition within the drilling industry. Beneath the surface are several factors which have brought about this dilemma.

1. Keep crews together

Contractors must do everything possible to keep crews together and "stay in the field." In recent years the driller has come to realize the value of crews who are trained to handle specific rigs and perform duties to suit the individual contractor. Such practices make far fewer accidents, less accounting, better maintenance of equipment and substantial savings in employment contributions and insurance rates. For this reason, the contractor is often willing to "trim a quarter" from the going field price.

2. Stay in one area

Moving and transportation costs often play an important part in determining a contract price. The contractor is inclined to bid lower for a series of wells, or hopes of drilling a group of wells in one area. Rig skidding and short, piecemeal moves play an important part in figuring costs for drilling a particular well. Crews often break up, and some are completely lost in long distance moves.

3. False accounting

Accounting practices are often responsible for inconsistencies in the drilling price structure. A failure to include costs of depreciation and replacement of equipment, with a reserve set aside for the "unforseen," has put more than one contractors operations in the loss column.

4. Blind bidding

Blind bidding has been the root of many failures. Drilling bids require a thorough knowledge of geologic structure to be drilled and a complete study of problems particular to an area. Consideration must be given not only to bit records of nearby wells, but price and availability of supplies, location and water costs (in some areas), and mud expense.

5. Interest taking

Drilling contractors sometimes lower drilling prices in turn for an interest in the well. Possibility for larger long-range return, in the form of royalty payments, result in a lower field price — if this price becomes known. For some unknown reason, the lowest price always becomes the going field price. Many large and strong companies have

Percentage comparison of drilling costs.

	1941	1945	1947	1948	1949	1950	1951	1952	1953	1954	1955
Labor costs	100	140	150	170	180	190	196	197	198	200	202
Equipment costs	100	110	132	145	160	175	180	183	188	190	195
Miscellaneous costs	100	120	160	165	170	175	181	185	188	191	194
Total rotary drilling costs	100	122	145	160	170	180	186	189	192	194	197
Drilling prices (footage basis)	100	115	110	105	101	100	103	103	102	99	96
Average drilling time (days)	100	95	85	80	75	65	60	59	58	56	56
Rate of penetration	100	110	130	140	150	170	180	182	184	188	188

United States contractor drilling trends.

	Total new wells completed	Total footage drilled	Average depth per well	Indicated work by contractors		
				Per cent	New wells completed	Footage drilled
1935	24,851	67,844,939	2,760	68	16,899	46,134,559
1936	28,962	80,996,816	2,797	69	19,984	55,887,803
1937	35,213	105,099,189	2,985	71	25,001	74,620,424
1938	29,127	90,585,158	3,110	71	20,680	64,315,462
1939	28,012	85,523,094	3,053	70	19,608	59,866,166
1940	31,149	96,182,605	3,088	71	22,116	68,289,650
1941	32,510	99,347,714	3,056	72	23,447	71,503,354
1942	21,990	67,903,053	3,088	70	15,393	47,532,137
1943	20,349	61,991,857	3,046	75	15,262	46,493,893
1944	25,786	84,378,457	3,272	78	20,113	65,815,196
1945	26,649	92,982,113	3,489	80	21,319	74,385,690
1946	30,230	101,124,813	3,345	81	24,486	81,911,099
1947	33,147	112,816,124	3,404	81	26,849	91,381,060
1948	39,477	136,709,153	3,463	82	32,371	112,101,505
1949	38,962	138,616,941	3,558	85	33,119	117,824,400
1950	43,204	159,393,997	3,689	88	38,020	140,266,717
1951	44,196	173,315,000	3,869	90	39,776	155,984,000
1952	45,879	189,389,000	4,060	91	41,750	169,614,000
1953	49,279	197,920,000	4,016	91	44,844	180,107,200
1954	53,650	215,940,250	4,025	92	49,358	198,665,030
1955*	57,500	232,530,000	4,044	92	52,900	213,927,600

* Estimated.

been formed through wise and organized combined drilling and production programs.

6. Sub-contracting

In certain areas, contractors have been successful in managing sub-contracts — subletting a contract, at a profit, to a driller who is willing to drill a particular well or wells at a lower price than the prime contractor can successfully offer with his own tools. This clever bit of horse-trading is possible only as long as the sub-contractor is willing to refrain from entering his own bids to the operator.

7. Non-profit drilling

Sometimes a rig, or a series of rigs are operated only as a device to "take deals," that is, drilling wells with no thought in mind as to profit coming from the operation of the rig. Any profit derived then must come through production obtained or money received in "turning the deal."

8. Use of inadequate equipment

In some cases, the operator will "buy" the use of a rig smaller than is necessary to drill a particular well. Money saved by using a rig that costs, say, $1200 per day to operate, rather than a rig which is rated to drill the specific hole, costing $1500 per day, has been responsible for some wells junked and abandoned. The drilling contractor who attempts to go beyond his capabilities is obviously endangering his own equipment and men, besides ruining the local price structure.

Whoever is responsible for the low drilling price, and such a price structure exists, drilling rigs may be expected to operate on closer budgets. This means fewer parts replacements, fewer improvements in present equipment to keep pace with new technology, and sub-standard practices the next alternative. The producer must eventually pay the cost of these cut-back prices. Until now the producer has been insured of a relatively good job on every well, and most certainly the biggest bargain in the industry.

Up until this past year, the drilling contractor could at least hope to trim costs by drilling the hole faster. The trend toward faster penetration levelled off last year. Since 1941, penetration rates have climbed steadily. In 1954 and 1955, however, this percentage rate (188 per cent of the 1941 figure) has remained the same.

There is an indication that while these footage penetration rates remained static, contractors were further expediting moving in and rigging up. Rig mobility is still being stressed, and is paying off in pre-and post-drilling time saved.

Any increased penetration rates that may have been brought about through the rise of new techniques, particularly in the field of air and gas drilling and slim hole drilling, have been lost in slower deep drilling. In 1955, the number of deep drilling operations skyrocketed.

Extent of this deep drilling is evident in the average hole depth last year. Average depth per well in 1955 was 4044 ft, about 10 ft deeper than the average for 1954. In 1952, the all-time average depth record was set. In that year the average was 4060 ft, a peak of a long trend. We are again following that trend with every indication for a deeper average this year, due to increased deep activity in many areas. Rig manufacturers substantiate this, although drilling rig sales from most quarters indicated more sales in the 6000 to 8000 ft class.

There are several bright sides to the 1955 drilling picture that must not be overlooked. The drilling contractors drilled more than 230,000,000 ft last year, with every indication that this figure will be exceeded next year, and for several years hence. Most of the producing companies favor continuation of an expanded drilling program. Consumption predictions call for increases of 4 per cent yearly. By 1970 the national demand is expected to be near 12,000,000 bbl yearly. Some predictions foresee 5 per cent increases, or a 14,000,000 bbl yearly consumption in 1970. A great deal of drilling will be required to maintain and increase our present oil reserves.

Number of drilling units appears to have levelled off last year, perhaps halting the snowballing list of contractors that has created much of the fierce competition among the drilling industry. Such a trend may be healthy. Fewer rigs: more wells to be drilled: increased demand: higher prices.

Of late, many contractors are learning their lessons on profit and loss. A current slump in Oklahoma, as reported in the Daily Oklahoman, may be due to checking of costs and stacking of rigs rather than compete in non-profit areas, although prices are still dipping. In one active field, contract prices have declined from $5.75 per foot on October 1, 1955, to $3.90 a foot now.

Is there an answer to the drilling contractor's plight? General increase in the price of crude oil cannot be expected to rise this year. Decreases in equipment, service and labor costs are not likely. A more realistic evaluation of drilling economics is inevitable. ★

In one well . . . 15 different logs, complete core analysis indicate what you can expect from . . .

Reservoir Evaluation by Log Interpretation

Charles R. Glanville
Sun Oil Company
Richardson, Texas

FOR any given field and under certain controlled conditions, interpretation of various type well logs can provide some of the data required to evaluate a reservoir. This is especially applicable to development-type wells. What logs will provide reliable data for this purpose, and just what kind of information can be derived from log interpretation for this problem in a given field? How does the reservoir data obtained from the various logging methods compare with carefully conducted field and laboratory core analysis?

These were among the questions when Sun Oil Company planned an extensive logging and core analysis program for the Felix Jackson No. 40 located in the Oyster Bayou field of Chambers County, Texas. Fifteen different types of logs were run in this one well—the entire pay section, commencing above the productive horizon, was cored under controlled conditions and thoroughly analyzed in both the field and in the laboratory. Careful interpretation of all logs to obtain some of the basic reservoir data was compared foot-by-foot with core analysis to determine its accuracy and reliability. Out of this extensive logging and core analysis procedure came some important findings as they apply to this particular reservoir and the manner in which the well was drilled. For one thing, it indicated the types of logs whose interpretation could provide satisfactory basic reservoir information in this well, and, secondly, from this study came a recommended evaluation program for any reservoir similar to the Seabreeze Sands at Oyster Creek.

Field History and Geology

Oyster Bayou field is located in southeastern Chambers County, Texas, about ten miles north of the High Island Dome. The geological structure is anticlinal, probably the result of a deep-seated salt dome. Oil and gas accumulations occur on the upthrown side of a major down-to-the-coast fault that is striking almost due north and south and limited by lesser east-west faulting to an area of about 1200 acres. Production is obtained primarily from the first massive sands below the Marginulina texana shore line (Frio), locally named the Seabreeze A-1 and A-2 Sands. These sands are connected through minor faulting and are operating as a single reservoir. The total productive volume is 260 ft, 200 ft of which is oil.

The discovery well was completed in April, 1941, and development was initially made on an 80-acre well spacing. In later development, fill-in drilling reduced the well spacing to 40 acres. There are presently 41 wells completed in the Seabreeze Sand reservoir. Productivity of the field is extremely high, and 400 bbl of oil per day on a ⅛-in. choke is the current well allowable. Original production was by a dissolved gas drive plus a natural water drive. Production is now obtained almost entirely by artificial water drive under a program of reservoir pressure maintenance by water flooding that began in 1951.

The Felix Jackson No. 40 well was drilled during July and August, 1953, as a fill-in well. Although drilled late in the field development, this well was selected for a very unusual coring and logging program. Procedure was to core the entire Seabreeze reservoir section using oil base mud and to log the same section by many different methods. An interesting situation was thereby created for a study of the usefulness of log interpretation of basic reservoir information in place of core analysis.

Operations

Drilling was begun using a mixture of clay and water as a drilling fluid. This mixture was treated with complex phosphates and quebracho, and clays were added to increase gelation during drilling. Mud tests indicated the following average properties in the 6576-to-8004 ft interval:

Weight 10.2 lb per gal
Viscosity 42 sec API
Water loss 10 cc/30 min
Cake 2/32 in.
pH 8
Chlorides 3300 ppm

A Schlumberger Electrical Survey was run to 8004 ft. By correlation of this log to the electrical logs of other wells, a coring point for the Seabreeze Sand section was picked at 8125 ft, and a 9⅞-in. hole was drilled to this depth.

For coring purposes, the water-base mud was displaced by a Black Magic oil-base mud. Diesel oil and Black Magic weight material were used in conditioning this mud. The following average mud properties were observed.

Weight 10.3 lb per gal
Viscosity 140-150 sec API

Coring began using a 9⅝-in. diamond bit to take 5¼-in. cores at 8125-8184 ft. This was followed by using a 7⅝-in. diamond bit to take 3¾-in. cores at 8184-8408 ft. The Seabreeze A-1 Sand was encountered at 8156 ft, this main sand development beginning at 8164 ft (Fig. 1). The following logs were made of the cored intervals:

1. Schlumberger 27-in. Induction Log, Type "E"
2. Schlumberger Gamma Ray-Neutron Log

The oil-base mud was displaced by a Lime-Kembreak fresh water mud so that other logs could be obtained. Caustic soda, Kembreak, lime, and Driscose were used to treat this mud, and sodium chloride was used to reduce its resistivity for logging purposes. The following mud properties were observed:

Weight 10.3 lb per gal
Viscosity 54 sec API
Water loss 4.8 cc/30 min

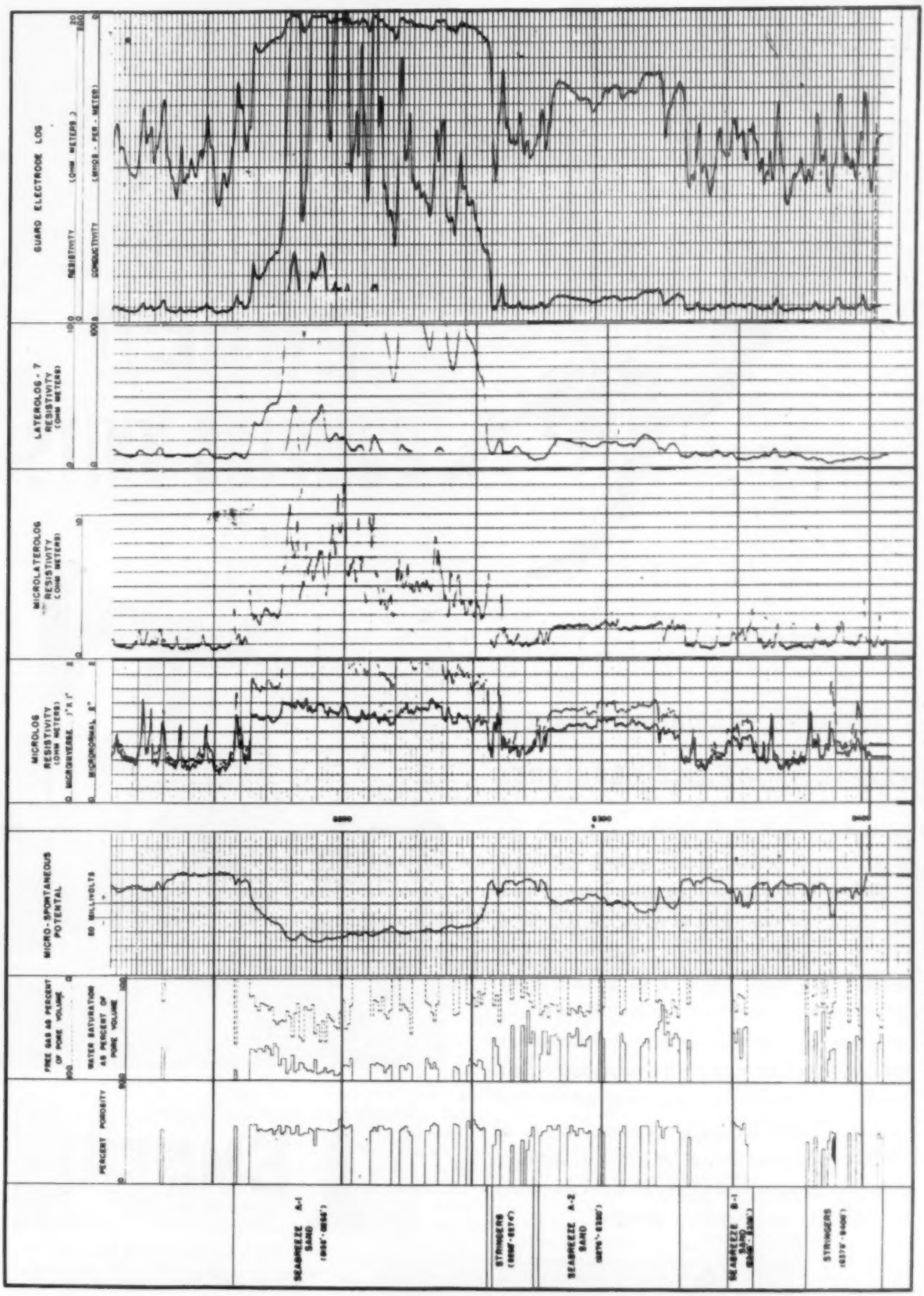

FIG. 1. **FULL LOG AND CORE ANALYSIS DATA** were obtained on the Seabreeze Sand Section at Oyster Creek, Chambers County, Texas. Five of the 15 logs run in the Felix Jackson No. 40 are compared with core analysis data.

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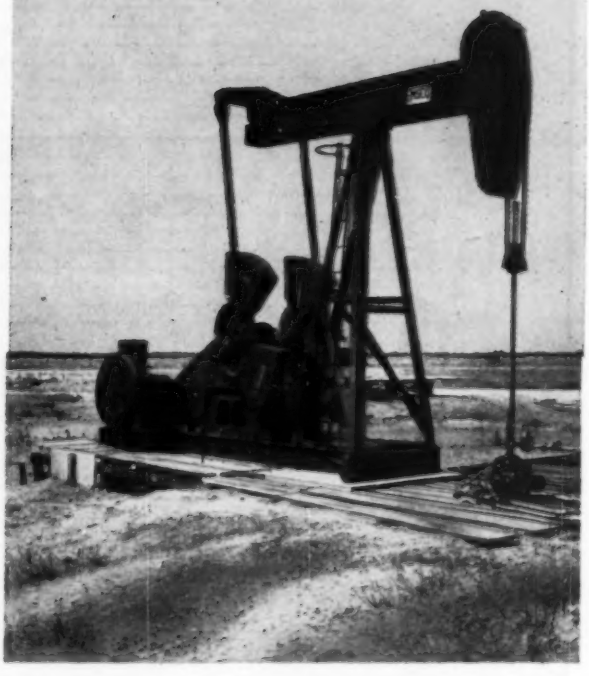

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Cake 2/32 in.
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Types of Electric Logs Run. Before logging, the hole was reamed to a 9⅞-in. diameter. The following logs were obtained in the order listed:

1. Schlumberger Electrical Survey with 16-in. normal, 64-in. normal, 56-in. lateral and 18 ft 8 in. lateral curves.
2. Schlumberger Mud Resistivity Log.
3. Schlumberger 3 in. LateroLog —3.
4. Schlumberger 18½ in. LateroLog — 7 with spread ratio of 2.6.
5. Schlumberger 8¾ in. Pseudo LateroLog—9 with spread ratio of 2.3 and return current spread of 48 in.
6. Schlumberger MicroLog with Micro S.P. Curve and Mud Log.
7. Schlumberger MicroLaterolog, Type "A" with Micro S. P. Curve.
8. Schlumberger 27-in. Induction Log, Type "E."
9. Halliburton Electrical Survey with 18 in. normal, 9 ft lateral, 16 ft lateral and 22 ft 6 in. lateral curves.
10. Halliburton Guard Electrode Log.
11. Halliburton Contact Log, Type 1, with Contact S.P. Curve.
12. Halliburton Caliper Log.

An attempt to obtain an experimental Halliburton Guard Contact Log was unsuccessful due to a mechanical failure of the tool. During the logging procedure, three Schlumberger fluid sample-taker bullets were fired. Only one of these (fired at 8205 ft) recovered formation fluids. It obtained a 39 cc mixture of water-base mud filtrate, formation water, formation oil and oil-base mud filtrate (oil).

With 7-in. OD casing set to 8408 ft, a Lane Wells Neutron Log with collar markers was obtained. Using this log for depth determinations, the Seabreeze A-2 Sand was perforated at 8312-8330 ft with 72 Lane Wells high-power bullets. On an initial potential test, the well produced 434 bbl of 36.3 deg API gravity oil per day with a gas-oil ratio of 432 to 1 through a 16/64-in. choke. Tubing pressure was 725 psi.

Core Analysis

Field Analysis. As each core was obtained, it was logged lithologically. With the exception of cores preserved for flow studies, each foot of sand was analyzed at the well site for wet density, free gas as a per cent of bulk volume, effective porosity, horizontal and vertical air permeability, and interstitial water saturation as a per cent of pore volume. The portion of each foot of core remaining after analysis was preserved in oil-base mud for future studies.

In determining the wet density and free gas saturation, core samples were broken in such a manner that they were free of mud and had a bulk volume of about 12 to 20 cc. Samples were weighed and inserted in a high-pressure mercury porometer where the bulk volume and void space under 750 psi pressure were determined.

The high-pressure porometer was also used to determine effective porosity by measuring the volume of a given sample and the amount of connected voids under 750 psi pressure. Samples used in this analysis were taken in the same manner as described above. They were chosen horizontally adjacent to the samples used for the free gas determination. Prior to the porosity measurement, each sample was cleaned of hydrocarbons by pulling carbon tetrachloride into it by vacuum and then out by vacuum. This process was repeated until the carbon tetrachloride showed no discoloration when it was removed from the sample.

Horizontal and vertical permeabilities were measured with a standard Ruska Flowreater permeameter on core samples shaped as ¾-in. cubes. These samples were first cleaned with carbon tetrochloride by the method described above.

For the measurement of interstitial water saturation, 100 gr of crushed sample were placed in a distillation flask. A toluene distillation continued for either one hour and forty-five minutes or until no more water came over, whichever took longer. Standard ASTM equipment was used in the distillation process.

Laboratory Analysis. In the laboratory, it was discovered that more residual oil and oil-base mud filtrate could be removed by Soxhlet extraction using a mixture of benzene and alcohol than by carbon tetrachloride cleaning as done in the field. Because of this, the same samples used in the field analysis of air permeability were re-cleaned by the laboratory method. Porosity determinations were obtained for these samples by the weight-saturation technique. Using these porosities, field determinations of free gas as a per cent of bulk volume were converted to free gas as a per cent of pore space. Also, redeterminations were made of interstitial water saturations.

Capillary pressure curves were run on several of the ¾-in. cubes used in the field analysis of air permeability and laboratory analysis of porosity. Most of the samples were from the A-1 Sand. Air was used to displace brine, and capillary pressure vs water saturation data were taken at seven different points. The maximum pressure was 32 psi, equivalent to a height of about 95 ft above the oil-water contact for an oil-water system.

High-pressure displacement tests are presently being conducted on two core sections of the A-2 Sand. Aim of this program is to obtain a comparison of the recovery efficiencies of the various production mechanisms.

Results. The A-1 Sand (8158-8256 ft) was found to be generally a clean, firm, fine to medium-grained sand. The upper 16 ft were shaly and calcareous, and a few tight streaks were encountered in the 8184-8204 ft interval.

Various stringers between the A-1 and A-2 Sands were shaly, soft and firm, fine-gained sands. The A-2 Sand (8276-8330 ft) was a shaly, hard, fine-grained sand, being limy at 8290-8292 ft. The B-1 Sand (8348-8356 ft) was a shaly, hard, fine-grained sand. Various stringers below the B-1 Sand were shaly, hard, fine-grained sands.

All sand sections had good hydrocarbon shows with sufficiently low interstitial water saturations that water-free production would be expected. By correlation to other wells, the gas cap appeared at 8158-8201 ft. All other sand sections were considered to be in the oil column. By the results of testing in other wells, the B-1 Sand appeared to be connected to the A-1 and A-2 Sand reservoir. It is not presently known whether or not the sand stringers below the B-1 Sand are a part of the same reservoir.

Porosity. Average effective porosities by core analysis of the entire Seabreeze section are shown below:

	Field measurement	Laboratory measurement
A-1 Sand (8158-8256 feet)	25.9 per cent	26.9 per cent
Stringers (8258-8274 feet)	18.5 per cent	22.6 per cent
A-2 Sand (8276-8330 feet)	23.2 per cent	27.2 per cent
B-1 Sand (8348-8356 feet)	26.5 per cent	27.9 per cent
Stringers (8379-8408 feet)	22.6 per cent	23.9 per cent

For the total section analyzed, the laboratory measurements gave a 2.1 per cent higher average porosity than the field measurements. The laboratory measurements are believed to be more reliable because the samples used were more thoroughly cleaned of hydrocarbons.

Water Saturation. Average interstitial water saturations by core analysis of the entire Seabreeze section are shown below:

	By field porosities	By laboratory porosities
A-1 Sand (8158-8256 feet)	21.0 per cent	17.4 per cent
Stringers (8258-8274 feet)	50.4 per cent	45.2 per cent
A-2 Sand (8276-8330 feet)	52.7 per cent	43.9 per cent
B-1 Sand (8348-8356 feet)	55.5 per cent	44.2 per cent
Stringers (8379-8408 feet)	48.0 per cent	43.6 per cent

FRACTURE
ACIDIZE
SWAB *and* TEST

as many intervals as required

... in one round trip

Product No. 677-C

with BAKER RETRIEVABLE BRIDGE PLUG *and...*

SETS AND PACKS OFF AGAINST PRESSURE DIFFERENTIALS FROM EITHER ABOVE OR BELOW

After the Retrievable Bridge Plug has been run to the desired depth and released, it will automatically set and pack off against pressure differentials established from either above or below the tool.

CAN BE RUN IN AND RETRIEVED EASILY... OR MOVED AND RESET AS MANY TIMES AS REQUIRED

The number of times that the Retrievable Bridge Plug can be released, moved and reset is limited only by the number of operations in the well that require its use.

NUMEROUS ECONOMICAL APPLICATIONS

Used WITH the Baker Full-Bore Retrievable Cementer for:

(a) *Straddle Operations*
The distance to be straddled is not limited by the made-up length of tool.

(b) *MULTIPLE Zone or Selective Testing, Fracturing, Acidizing*

Used BY ITSELF for:

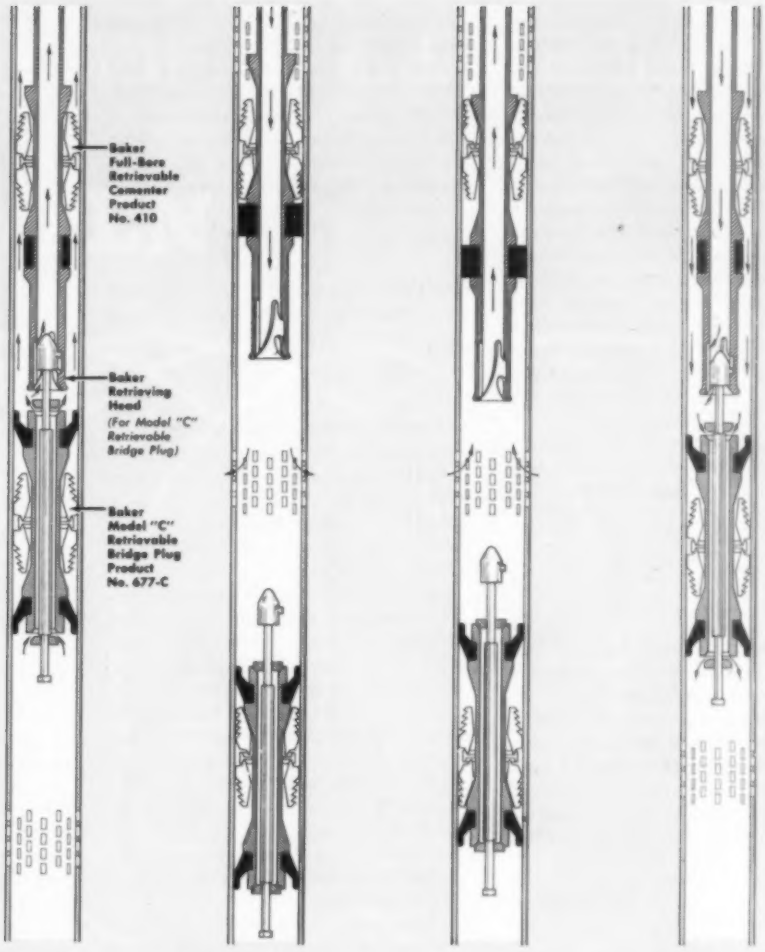
(a) "Down-the-casing" Fracturing or Acidizing

(b) Testing operations

(c) Temporary pressure containment to permit repair to or removal of well head equipment with safety.

Write for Catalog Supplement No. 319 for complete information on

TYPICAL OPERATION


Baker Full-Bore Retrievable Cementer Product No. 410
Baker Retrieving Head (For Model "C" Retrievable Bridge Plug)
Baker Model "C" Retrievable Bridge Plug Product No. 677-C

RUNNING-IN
Retrievable Bridge Plug being run into well on bottom of Full-Bore Cementer through use of Retrieving Head. Note fluid by-pass.

FRACTURING OR ACIDIZING
Plug should be pressure tested after release. Cementer is released, raised above perforations and reset for pressure operations.

SWABBING, TESTING
Note how the reversal of pressure differential has transferred load from one set of slips to the other (both cementer and plug).

RETRIEVING
Plug and Cementer being moved to next set of perforations—or retrieved from well. Valves in plug open to permit fluid by-pass.

Product No. 410

BAKER FULL-BORE RETRIEVABLE CEMENTER

HOLDS PRESSURE FROM EITHER ABOVE OR BELOW

Two sets of opposed slips enable the cementer to hold pressure from either above or below. Casing can be tested before squeeze—and the tubing also, if the Baker Full-Bore Tubing Tester is used.

FULL BORE CONSTRUCTION

Permits Passage of Tubing Perforators or Instruments—Assists in Preventing "Screen-Out" on Fracturing Jobs

The Full Bore through the Cementer (and Tester if used) is in reality a continuation of the bore through the tubing.

This continuous full ID passage not only permits passage of tubing perforators or instruments but assists in preventing "Screen-Out" (sand dropping out of the oil) and subsequent plugging of the tubing in fracturing jobs.

IDEAL STRADDLE TOOL WHEN USED WITH BAKER RETRIEVABLE BRIDGE PLUG

The operation of the Cementer setting mechanism makes it easy (through the use of the Retrievable Bridge Plug Retrieving Head) to release and pick-up the Baker Retrievable Bridge Plug. It is in fact the ideal partner to the Retrievable Bridge Plug for selective multiple-zone or single-zone operations.

these products and their application

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For the total section analyzed, calculations based on laboratory porosities gave an 8.1 per cent lower average water saturation than the calculations based on field porosity measurements. The lower saturations are considered to be more reliable, of course, since they are based on more reliable porosities. Use of one sample to determine porosity and another to measure water content is one source of error to consider in either calculation since it is assumed that the two samples have identical porosities. However, for thick sections such as the A-1 and A-2 Sands where a large number of measurements are involved, this error probably had little effect in the overall average.

Permeability. Average air permeabilities by core analysis of the entire Seabreeze section are shown below:

	Horizontal	Vertical
A-1 Sand (8158-8256 feet)...	2188+ md	1955+ md
Stringers (8258-8274 feet)....	217 md	212 md
A-2 Sand (8276-8330 feet)...	218 md	127 md
B-1 Sand (8348-8356 feet)...	352 md	325 md
Stringers (8379-8408 feet)....	206 md	190 md

Average permeabilities for the A-1 Sand are inexact because numerous samples had permeabilities bevond the range of the permeameter, 3702 md.

Irreducible Water. Average irreducible water saturations (at 32 psi capillary pressure, equivalent to 95 ft above the oil-water contact) by core analysis of the entire Seabreeze section are shown below.

	Water saturation
A-1 Sand (8158-8256 feet).....	14.9 per cent (48 samples)
Stringers (8258-8274 feet).....	42.2 per cent (3 samples)
A-2 Sand (8276-8330 feet).....	34.5 per cent (9 samples)
Stringers (8379-8383 feet).....	47.3 per cent (2 samples)

Since the entire section is more than 95 ft above the original oil-water contact, it is interesting to note the reasonably close agreement between the irreducible water saturations and the original water content of the cores (based on laboratory porosities). The most valid comparison would apply to the A-1 Sand where a large number of measurements were obtained by each method. For this case, the capillary displacement gave a 2.5 per cent lower average water saturation. Basically, determinations of original water content of the cores are believed to be more reliable indications of in-place water saturations. It is unlikely that formation water was displaced in obtaining the cores since they were taken so high above the original oil-water contact using an oil-base drilling fluid.

Log Interpretations

Detailed quantitative interpretations for the determination of formation factor (a function of porosity) and interstitial water saturation were made of the various electrical logs. These analyses were limited to the 8176-8255 ½-ft interval (approximately 80 per cent of the A-1 Sand) where no appreciable shales were encountered. The basic Archie equation was applied, which relates the water saturation of the permeable bed (S_W) to its resistivity (R_t), formation factor (F), water resistivity (R_W) and saturation exponent (n):

$$S_W = \left(\frac{F \times R_W}{R_t}\right)^{1/n}$$

The formation factor is also expressed as a function of porosity (ϕ) and cementation exponent (m):

$$F = \left(\frac{1}{\phi}\right)^m$$

Core analysis. For use in the log interpretations, the formation factor and porosity were measured on a single core plug (1-in. diameter by 1-in. length) taken from approximately each fifth foot of the interval studied. Porosities were obtained by the weight-saturation technique. Formation factors were measured for two sodium chloride solutions, one having a resistivity approximating that of the Lime-Kembreak mud filtrate (0.36 ohm-meter @ 75 F) and one having a resistivity approximating that of the formation water (0.057 ohm-meter @ 75 F). Slightly lower formation factors were obtained for the fresher brine, indicating that there were sufficient disseminated clays present to affect the resistivity of the flushed zone adjacent to the well bore.

An average cementation exponent of 1.8 was determined for the mud filtrate brine and 1.9 for the formation water brine. These exponents were used to convert all available laboratory core analysis porosity data to formation factor data.

MicroLaterolog. Formation factors were computed from the MicroLaterolog and compared to the formation factors obtained by the core analysis. The procedure was to pick resistivity values from the log with as much detail as possible. By this method the 79½-ft interval was broken into 58 individual sections. Each log value was corrected for mud cake effects using Doll's correction chart[1] for the type "A" MicroLaterolog to obtain the true flushed zone resistivity. In most cases, correc-

The Author

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This important paper was presented under the original title "Formation Evaluation of Felix Jackson No. 40 Well, Frio Formation, Oyster Bayou Field, Chambers County, Texas" by the author at the Formation Evaluation Symposium sponsored by the Gulf Coast Section of AIME at The University of Houston in October, 1955.

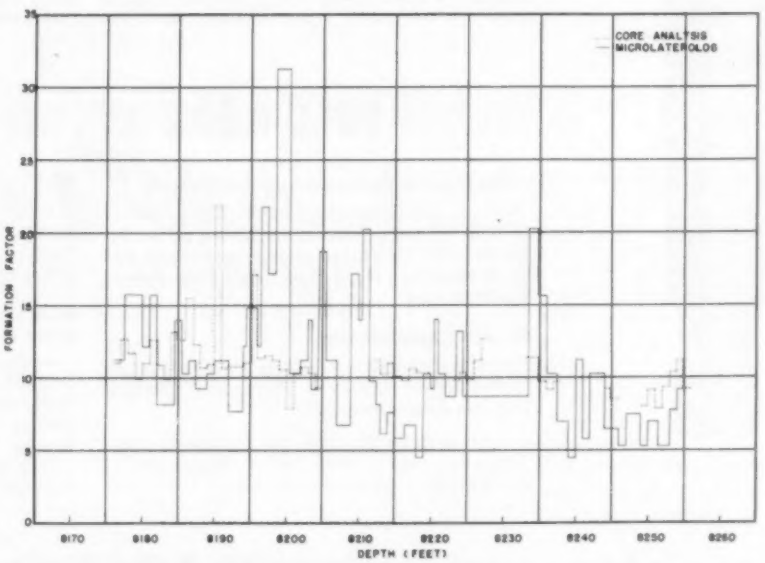

FIG. 2. **COMPARISON OF FORMATION FACTORS** by core analysis and by MicroLaterolog interpretation.

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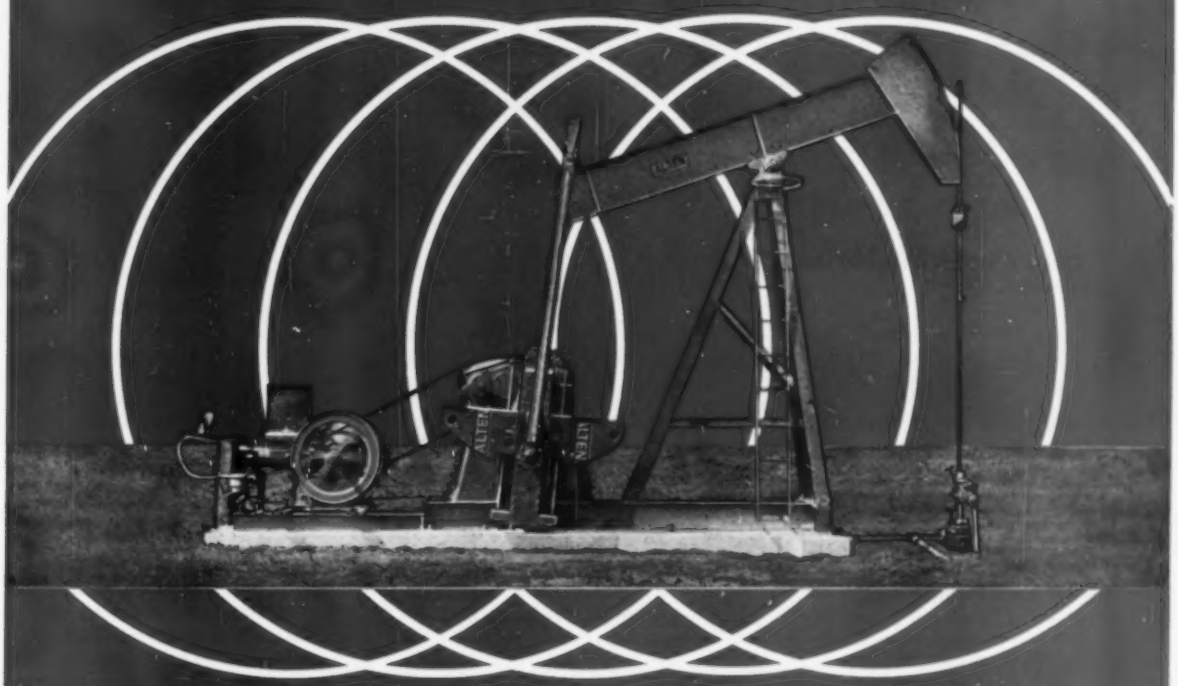

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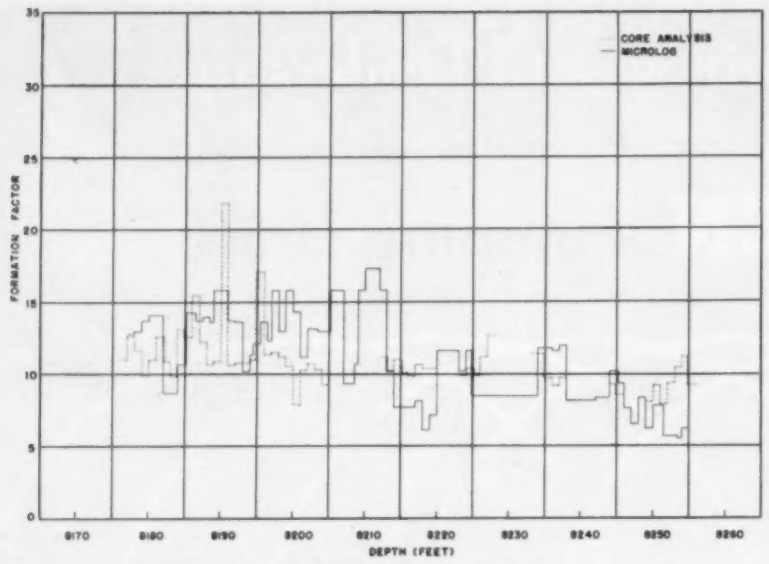


FIG. 3. **COMPARISON OF FORMATION FACTORS** by core analysis and MicroLog interpretation.

tions were less than 10 per cent.

Mud cake thickness was obtained from the Caliper Log by assuming that the hole diameter was equal to the reamer diameter. Mud cake resistivity (0.60 ohm-meter at formation temperature, 164 F was obtained from the Schlumberger measurement at the well site. The "apparent" formation factor (no residual hydrocarbon correction applied) was determined in each case from the ratio of the flushed zone resistivity to the mud filtrate resistivity (0.18 ohm-meter @ 164 F), also measured at the well site.

Effects of residual hydrocarbons upon the resistivity of the flushed zone were determined by comparing the average "apparent" formation factors to the average formation factors determined by core analysis (with cementation exponent of 1.8 applied). The ratio between the average "true" formation factor to average "apparent" formation factor for the entire 8176-8255 ½-ft interval was 0.28, indicating an average residual hydrocarbon saturation of 51 per cent for a saturation exponent of 1.8. Each "apparent" formation factor was corrected for residual hydrocarbon effects by multiplying by 0.28.

Comparison of MicroLaterolog formation factors to core analysis formation factors was very poor (Fig. 2). Failure of the MicroLaterolog to give a more reliable interpretation has been attributed to the existence of a very small radius of mud filtrate invasion that had not uniformly flushed the formation of hydrocarbons at the time of logging. Lack of effective flushing is apparent in the requirement of the 51 per cent average residual hydrocarbon correction since the usual MicroLaterolog interpretation requires a correction of 30 per cent or less.

MicroLog and Contact Log. Formation factors were also computed from the MicroLog and Contact Log and compared to values determined by core analysis. As in the MicroLaterolog interpretation, resistivity values were picked with as much detail as possible. For the Microlog, there were 61 individual sections analyzed, and for the Contact Log there were 26. Greater detail of the MicroLog interpretation is partly attributed to the use of 25-in. = 100-ft scale. The MicroLaterolog and Contact Log were recorded on the 5-in. = 100-ft scale only.

In obtaining flushed zone resistivities, Schlumberger Document No. 5B was applied to the MicroLog interpretation, and the Halliburton Document, "The Contact Log," was applied to the Contact Log interpretation. By the same method applied to the MicroLaterolog interpretation, it was found that a residual hydrocarbon correction of 53 per cent was applicable to the MicroLog interpretation and a correction of 43 per cent was applicable to the Contact Log interpretation.

Comparisons of MicroLog and Contact Log formation factors to core analysis formation factors were poor (Fig. 3 and 4). These results also indicate non-uniform removal of hydrocarbons in the flushed zone at the time of logging.

LateroLog — 3, — 7 and Guard Electrode Log. Interstitial water saturations were calculated from the LateroLog—3, LateroLog—7 and Guard Electrode Log by assuming the logs gave true resistivity indications of the virgin formation, being unaffected by mud filtrate invasion. Formation factors applied in the Archie equation were those obtained by core analysis for the formation water brine. For each individual section analyzed, the harmonic average of the corresponding formation factor values was used. Water resistivity (0.026 ohm-meter @ 164 F) was an average measured value of numerous produced water samples from other wells in the field. A saturation exponent of 1.8 from a statistical average measurement of similar formations was assumed.

For intervals in which core analysis was available, the LateroLog —3 gave

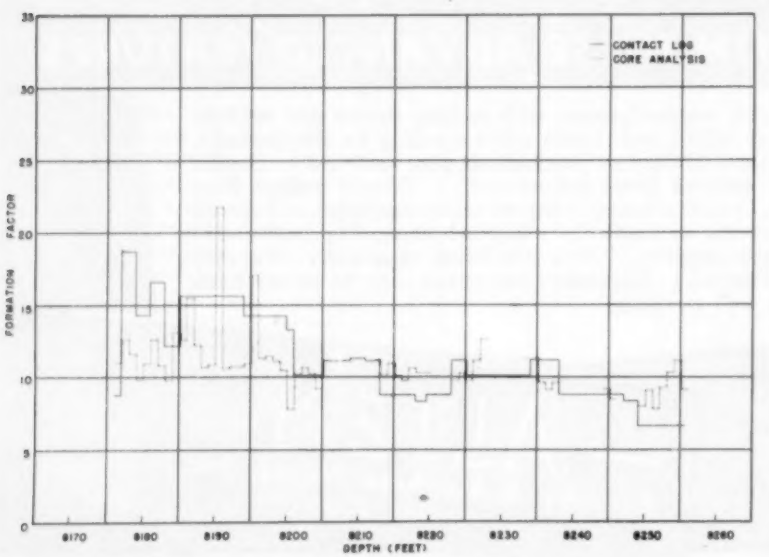
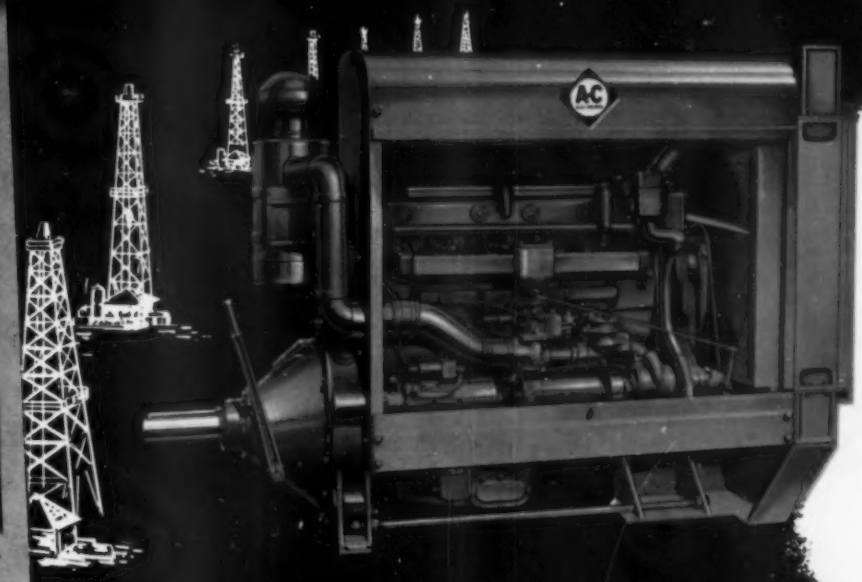


FIG. 4. **COMPARISON OF FORMATION FACTORS** by core analysis and by Contact Log interpretation.



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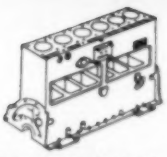

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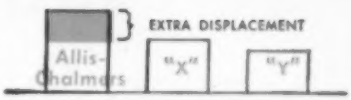

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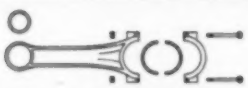

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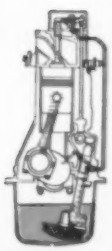

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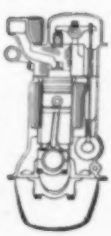

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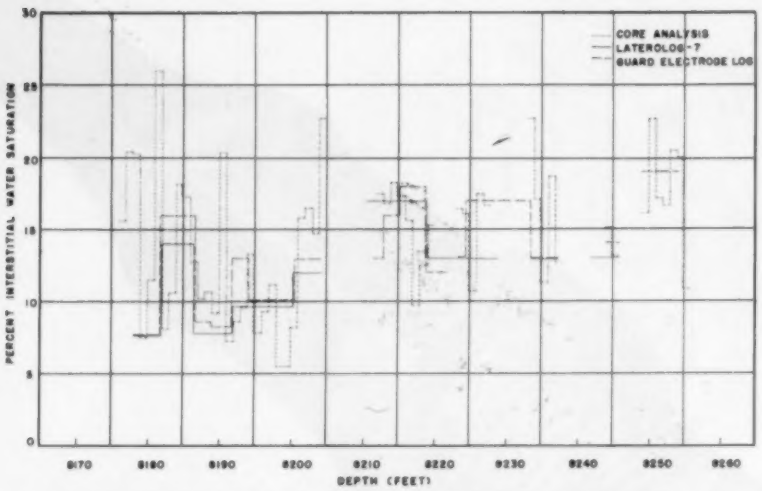


FIG. 5. **COMPARISON OF INTERSTITIAL WATER SATURATIONS** by core analysis and by LateroLog-7 and Guard Electrode Log interpretations.

an average water saturation of 13 per cent compared to a core analysis average water saturation of 14 per cent. The LateroLog-7 gave an average water saturation of 12 per cent and the Guard Electrode Log gave 14 per cent. A graphical comparison of core analysis and log interpretations in Fig. 5 shows that the Guard Log gave approximately 50 per cent more detail than the LateroLogs.

Pseudo LateroLog-9. An inspection of the Pseudo LateroLog-9 revealed that it had very nearly identical quantitative characteristics of the LateroLog-7. This comparison was considered to be further evidence that the radius of mud filtrate invasion was very shallow at the time of logging since this log should have had a smaller radius of investigation than the LateroLog-7.

Electrical Surveys. Interstitial water saturations were calculated from the 18 ft 8 in. lateral curve of the Schlumberger Electrical Survey and the 16 ft and 22 ft 6 in. lateral curves of the Halliburton Electrical Survey. Resistivity values were selected only in sections where inherent adjacent bed effects were not thought to be serious. Bore hole corrections were applied to these resistivities using the Schlumberger Document No. 3, "Resistivity Departure Curves." The mud resistivity value (0.27 ohm-meter @ 164 F) was obtained from the Schlumberger measurement at the well site. Little detail was obtained in these interpretations, which gave 4 to 5 per cent lower average water saturations than the core analyses of the corresponding sections.

Induction Logs. Interstitial water saturations were calculated from Induction Logs by assuming their resistivity indications were unaffected by the mud filtrate invasion. These analyses gave 3 to 4 per cent lower average water saturations than the core analysis. Detail of the interpretations was comparable to that of the LateroLogs. Average resistivities observed on the log run in the oil-base mud were slightly higher, indicating that there were some bore hole effects on the run obtained in the Lime-Kembreak mud.

Neutron Logs. For each of the Neutron Logs, an attempt was made to establish a correlation between porosity and neutron deflection by plotting core analysis porosities on a logarithmic scale vs neutron deflections on a linear scale. This was applied in the interval below the gas cap only. A slight trend was noted in the correlation with the larger neutron deflections corresponding to the smaller porosities. However, the data were considered to be too badly scattered about the correlation line for use in reservoir evaluation.

Log Interpretation vs Core Analysis

The extensive core analysis program conducted in the Felix Jackson No. 40 Well has contributed important basic data for the evaluation of the Seabreeze Sand reservoir of the Oyster Bayou field. The logging program has been important in determining the logging methods that can be used to obtain some of the basic data ordinarily obtained by core analysis.

Cause of poor MicroLaterolog, MicroLog and Contact Log interpretations has been attributed to the existence of a very small radius of mud filtrate invasion that did not thoroughly flush the rock material adjacent to the well bore of hydrocarbons. Evidence of poor flushing is shown by large residual hydrocarbon corrections necessary to calibrate log interpretations to core analysis. Evidence of shallow invasion is shown by: (1) Good results of interstitial water interpretations from the LateroLog-3, Laterolog-7 and Guard Electrode Log in which no corrections were made for the effects of mud filtrate invasion, (2) striking similarity of the LateroLog-7 and Pseudo LateroLog-9, and (3) recovery of formation water by a Schlumberger fluid sample-taker bullet.

Filtrate Invasion Shallow. The primary reason that invasion would be shallow at the time of logging is the fact that a total of only 16 hr had elapsed between the time that reaming of the cored interval began and the time that logging began. For such a small interval of time, during one-half of which the mud was not being circulated, it is not believed that the filtrate of the low water-loss mud would give any appreciable invasion of the high-porosity formation. Thus, removal of hydrocarbons in the flushed zone would be expected to be non-uniform and incomplete.

It is interesting to note that the interpretations of the micro-type logs gave indications of the gradual removal of hydrocarbons adjacent to the well bore. The MircoLog, first of three logs to be run, gave a 53 per cent residual hydrocarbon saturation. The MicroLaterolog, run a short time later, gave a 51 per cent saturation. The Contact Log, run at least 8 hr after the MicroLaterolog, gave a 43 per cent saturation.

Intersitial Water. Interpretations of the LateroLog-3, LateroLog-7 and Guard Electrode Log indicate that these tools could well be used to determine interstitial water saturations in the clean section of the Seabreeze A-1 Sand. The Guard Log is shown to produce the most accurate and most detailed information. These interpretations require a knowledge of formation factor. Such information could be obtained from cores taken in water-base mud. It is also likely that for proper conditions of mud filtrate invasion, the MicroLaterolog would yield reliable formation factor data. Use of this log would be preferred to using the MicroLog or Contact Log since it gives greater detail (Fig. 1) that is also helpful in selecting intervals for the analysis of LateroLogs or the Guard Log.

Evaluation Program. Following are the essential elements of a recommended evaluation program for any reservoir similar to the Seabreeze Sands of the Oyster Bayou field. In the immediate area, this would apply to the Willow Slough, Seabreeze, Fig Ridge, Stowell and Anahuac fields where reservoirs of the same Seabreeze Sands exist.

1. A group of key wells should be chosen to obtain representative data for the entire reservoir. These wells

should be cored, a few with oil-base mud and the others with water-base mud.

2. All wells should be logged with a LateroLog (or Guard Electric Log) plus a MicroLaterolog. The Neutron Log with collar markers should be run for completion purposes. Electrical Surveys should be run in a very few wells for correlation purposes.

3. For drilling the reservoir section, a low water-loss, low-resistivity mud should be used so that more reliable log interpretations could be obtained. It would be desirable that approximately the same mud be used in each well.

4. Core analysis should include lithological descriptions, free gas saturation, water saturation, porosity, permeability, and capillary pressure curves for each foot of sand recovered.

5. Each MicroLaterolog should be interpreted to obtain formation factor and porosity data. Each LateroLog (or Guard Electrode Log) should be interpreted to obtain interstitial water data. Reliability of log interpretations should be decided by their comparisons to core analyses. Such comparisons should also decide whether or not the log interpretations could be extended to the shaly sections. Log interpretations of all non-cored wells should be used to obtain net sand figures.

6. In a program of water flooding, a few wells should penetrate the water-flooded section. It is believed that reliable interpretations of oil recovery could be obtained from the LateroLog (or Guard Electrode Log) of this section.

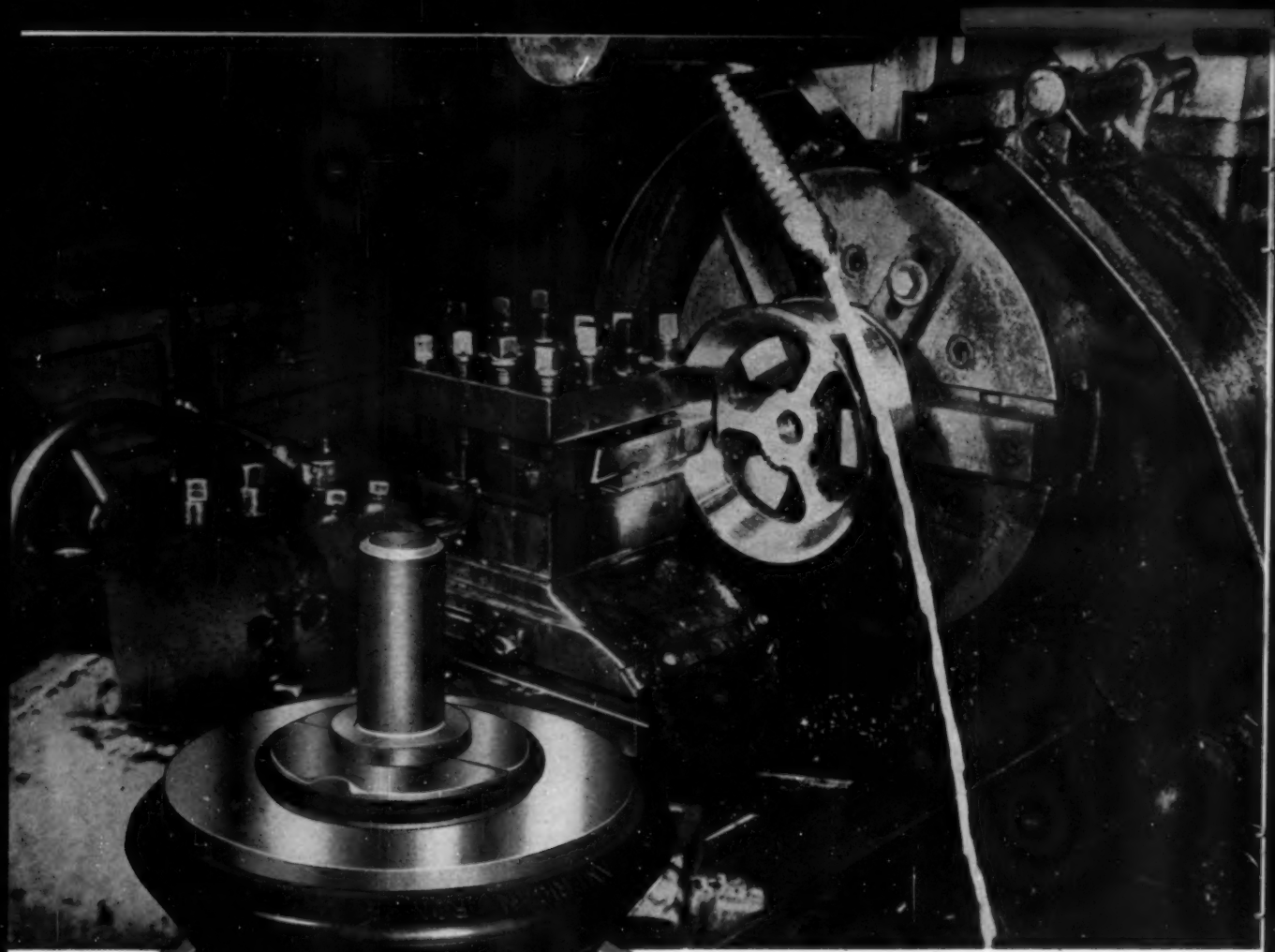
7. The testing program should be adequate enough to establish gas-oil and oil-water contacts and the productive capacity of the reservoir. Log interpretations to locate fluid contacts should be used wherever possible in place of tests.

Acknowledgment

Acknowledgments are due various individuals of the Gulf Coast division of the Sun Oil Company — to K. E. Montague, F. W. Brupbacher and W. B. Junod in setting up the coring and logging program, to H. W. Perkins in setting up the mud program, to Burpbacher in analyzing the cores and supplying data that made this report possible, and to W. B. Junod for supplying the geological information. Acknowledgments are also due each of these individuals and J. E. Goodson for their helpful suggestions and criticisms in the preparation of the report.

Reference

1. Doll, H. G., The Microlaterolog, Trans. AIME, 1953, Vol. 198, p. 17.



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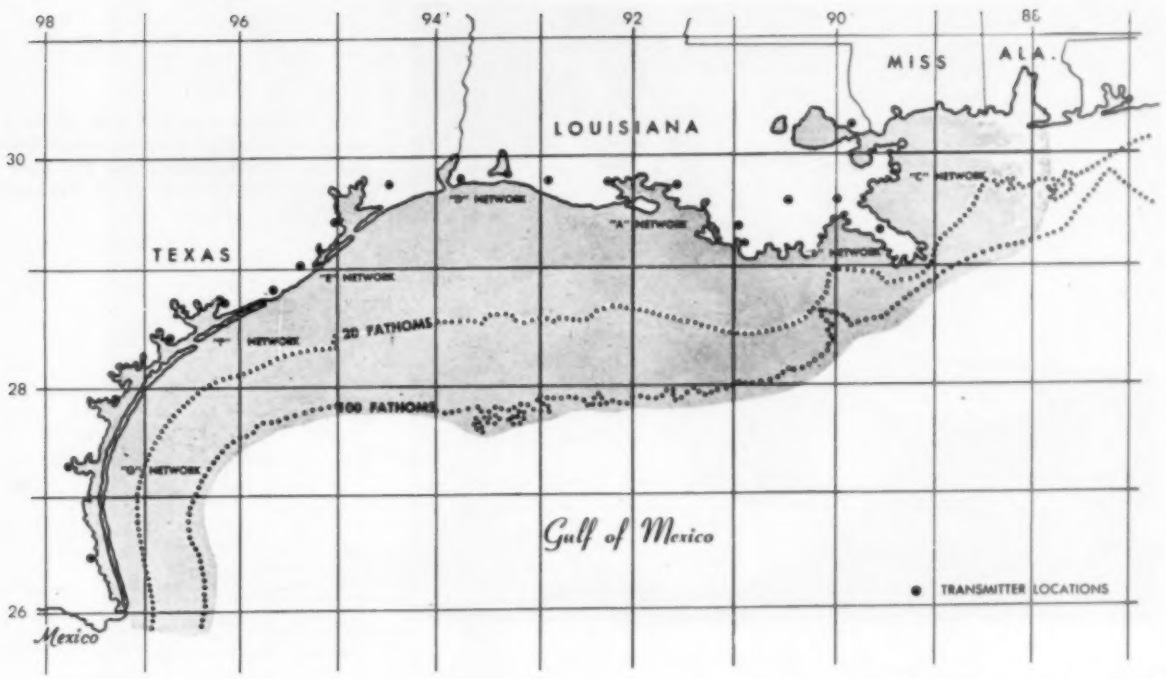

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Take the problem of aerial magnetometer surveying offshore areas along the Gulf Coast. It is desired that the survey be made over a large area. Grid lines are drawn on a map. They are spaced from ½ to 1 mile apart, and are 50 to 70 miles long roughly at right angles to the coast line and extending approximately 50 miles offshore. If the aircraft carrying the sensitive magnetometer instruments could fly at a prescribed constant altitude and exactly on prescribed courses, interpretation of results would be simplified and more accurate. It is difficult, however, to maintain an aircraft exactly on a course charted on the map.

A new electronic device to aid in navigating the aircraft along a prescribed course has been developed by Seismograph Service Corporation of Tulsa, Oklahoma. It is called the Actrac (accurate tracking) Flight Display Unit and is used in conjunction with SSC's Lorac precision electronic positioning system. The Lorac positioning system has been used for several

FIG. 1. Actrac unit that plots courses of plane on chart showing preplotted course by which navigator can compare actual position with desired position.

years in making seismic surveys in the Gulf of Mexico. This method of positioning vessels on the water beyond the sight of land is essentially an electronic system that employs three transmitter and receiving stations located at known positions on land. Relatively low frequencies are utilized that travel the contour of the earth and not on a "line-of-sight" path. The course that a vessel on water travels is accurately plotted by means of the Lorac system.

In the case of making aerial magnetometer surveys, it is desired that the aircraft fly as closely to a prescribed course as possible to increase accuracy of interpretation. The tracking device was developed to tell the pilot when he is off a prescribed course, how far off he may be and in what direction. The information is supplied immediately enabling him to steer the aircraft in the right direction and to correct distance. By constantly knowing the course prescribed and exactly where he is in relation to the prescribed course, the pilot then may get back to the prescribed course without delay.

How It Works. The prescribed course is drawn on the chart paper used by the tracking unit. In flight, the course of the aircraft is plotted accurately and automatically by the device. The navigator who constantly observes this chart can transmit the information to the pilot to tell him how far off he may be from the prescribed course and in what direction, whether to the left or to the right.

These lines of the prescribed course are laid out on the chart paper in advance with movement of the chart representing one coordinate and the position of a mark across the width of the chart representing the other coordinate. Chart drive speed is fast enough to track an aircraft at speeds up to 150 mph. Any desired scale may be obtained in the direction of chart movement since a chart length of 125 ft may be accommodated in the chart magazine.

To obtain an adequate scale across the chart width, a flyback arrangement is used to effectively increase the chart width to any desired amount. Most courses thus will provide a sawtooth curve on the chart (Fig. 2). Zero flyback time of the second coordinate is obtained by using a drum with a helix wire on it and a marker bar across the chart. When the line produced by the marker bar and helix wire reaches one side of the chart, the helix wire starts to mark on the opposite side of the chart.

By this unique combination of coordinate presentation, a display of any desired flight path may be made to an accuracy limited only by the Lorac system accuracy. Size of the display unit does not prevent a high accuracy of presentation since only a small portion of the total flight path is being displayed at any one time.

Lines are laid out in advance on the chart paper, and as the aircraft flies along a line of position, the track being made on the chart is compared with the preplotted line. If the pilot is flying to the left or right of the desired course, the navigator presses a button

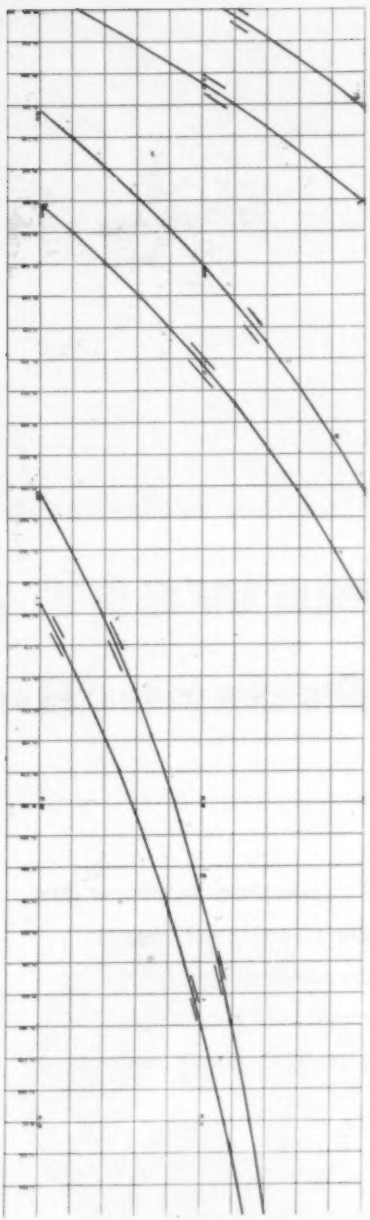
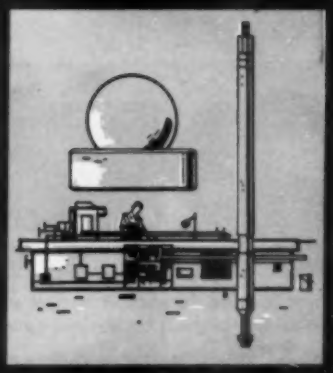


FIG. 2. Preplots of two parallel lines on chart for Actrac display unit.



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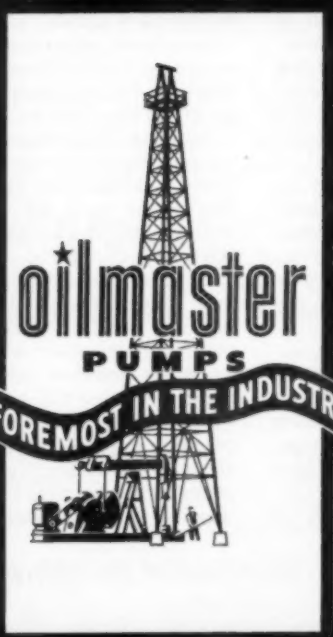

singleness of purpose

A company
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that causes a lamp to light in the pilot's compartment on the pilot's deviation indicator (PDI) unit shown in Fig. 1, indicating that the pilot should steer the plane to the left or right and approximately how much.

There is a zero button that indicates "on course," and it is used when the plane is exactly on course. Deviation buttons are for 50, 100, 150 and 200 ft to both the left and right. The navigator constantly compares the position of the aircraft as indicated by the track being drawn on the chart paper with the desired tract laid out on the paper. He constantly notifies the pilot of the plane's course in reference to the preplotted course by means of the deviation indicator.

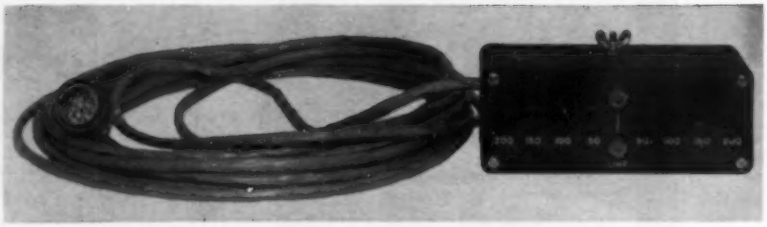
Either standard chart paper, which is marked with a pencil lead, may be used or any one of several types of electro-sensitive papers that are marked by voltage-energized electrodes.

Other Uses. The instrument was designed primarily for use of fixed-wing aircraft flying straight lines, but is not necessarily limited to that use. It has many other possibilities such as: (1) Fixed-wing aircraft flying any desired course, (2) helicopters flying any desired course, (3) marine vessels working in heavily congested harbors and areas that have restricted channels through them, and (4) hydrographic surveys where it is desired to navigate specific lines.

In addition to its use as a device to enable aircraft or marine vessels to follow preselected paths, the Actrac unit may be used to record the paths traveled whether or not any preselected path was involved. By examining the record of the path, one can determine the exact route traveled, so long as that route was in an area that was covered by Lorac radiolocation signals.

Operation. Only a few simple controls are required for operation of the unit. Reset controls are provided for both the chart and the pen. The chart reset drives the chart in either direction as required to properly position the chart with respect to the position of the craft employing the Actrac for positioning.

The pen reset rotates the drum with the helix wire in the proper direction as required to position the marker properly. The power switch serves to turn the power to the unit off and on. The pen servo and chart servo switches are turned on to energize the servo circuits when the craft is within 20 lanes of the correct starting position. With the craft near the correct starting position, turning these switches on will cause the chart and helix marker immediately to assume correct positions. The "marker on" switch is provided to release the marker bar so that the course will be plotted. This switch is turned on only when the craft is near the starting position and it is desired to start plotting the position.



Pilot's deviation indicator located in cockpit to tell pilot how much and in which direction plane is off desired course.

The PDI plus-minus switch is used to interchange the connections to the PDI unit when a reversal in direction of travel takes place. This insures that lamps on the PDI unit always indicates left and right correctly. Deviation buttons on the front of the Actrac unit are depressed by the navigator if the craft deviates from the desired course, and they indicate to the pilot the amount of deviation. Counters are provided to insure the readings of the chart and the marker so they can be compared with those of the normal indicator.

This new electronic navigational aid plays a dual role — to guide the pilot on a prescribed course and to record the actual line of flight. For reference checking, a movie camera photographs the corresponding Lorac meter readings every 20 sec. ★ ★ ★

Canada to Prosper In 1956, Thanks to Oil Industry

Greatest year in its history faces the Canadian oil industry during 1956 and many other industries throughout the country will prosper as a result. This was predicted here today by Vernon Taylor of Calgary, representing the board of governors of the Canadian Petroleum Association, in an address to the Canadian Construction Association.

Indications are that activity in the oil business in 1956 will surpass even the record levels of 1955 in all phases of the industry, the speaker asserted. He spoke of the oil industry's influence on the economic life of Canada as a whole.

"The growth of the oil industry," said Taylor, "has led to the development of a host of new businesses to help supply its needs. This is partly the result of the oil industry being the most automated in the world. It is estimated that some $35,000 of equipment is needed for every man on the job and in big modern refineries the figure is far higher."

Providing this expensive array of working tools for oil men has been largely the function of literally thousands of other Canadian businesses, many of them new to the country or older firms tackling new jobs, the speaker said.

He added that there has been expansion of steel fabricating firms to meet the demands for new refinery equipment and tankage, new expansion in firms making or dealing in pipe, valves, instruments, meter equipment and scores of other items.

Taylor, predicting the growth of capital investment in the petroleum industry, said, "Many industry experts believe this year will see investments reach the highest level yet, but that the rate of increase in spending to the end of 1960 may be somewhat less than over the past nine years. Even so, it is expected that in excess of a billion dollars will be required to support the demand growth over this period.

"There were 156 geophysical crews active throughout Western Canada, as 1955 closed," Taylor said. "This was 16 more crews than were in the field as 1954 ended and indicated a new high in winter operations in this branch of exploration.

"Similarly, in the actual drilling of exploration and development wells, there were 231 rigs scattered over thousands of square miles probing for elusive crude pools or engaged in development drilling. Because of developments on the gas export front, it is expected drilling will be stepped up in some areas. This is likely, for instance, in northeastern British Columbia, where a definite start on the gas pipe line to the coast will accelerate the drilling pace there and in the Peace River area of Alberta.

"There are other projects which will keep construction men busy, such as a chemical plant at Medicine Hat, the gas processing plant scheduled to go up in the Redwater field, the sulphur plant at Pincher Creek, and no doubt other building programs are in the planning stage. Taken as a whole, all these various undertakings should help make 1956 one of the biggest business years in Canada's history."

How To Correct . . .

Orifice Plate Errors Due to Pulsative Gas Flow

Acoustic method used to develop basis for evaluating amount of deviation

Charles Newman
The Fluor Corporation, Los Angeles, California

A METHOD has been developed for correcting conventional orifice plate calculations for pulsative gas flow. It is based on an analysis of the velocity conditions in and around an orifice plate under pulsative gas-flow conditions and a study of the errors introduced by the use of the assumption of steady-state gas flow conditions.

Conventional calculations of flow rates form orifice-type meters are based on the assumption of steady-state flow conditions. The presence of pulsations requires that a different basic assumption be made, or that a correction factor be applied to conventional orifice calculations. Work of previous investigators[1,2] was concentrated on the errors of the secondary element — the indicating or recording device. Some work[3,4] has been done on the errors of the primary element — the orifice plate itself.

Theory of Measurement

Consider first what measurements might be made on the gas before flow is initiated in it. The molecules are, on the average, at rest. They do have random motion, but there is no set movement of the gas in any direction. Hence, the net displacement is zero. It follows that the net velocity is zero. Also, when there is no flow, the pressure throughout is constant and is equal to the static pressure.

Smooth Flow. When a constant force is applied to the gas from left to right, several measurable changes occur. The particles are accelerated, and as a result, are displaced from their rest positions. This action produces a constant velocity v of the gas from left to right, and now the static pressures at, pipe or flange taps, points A_1 and A_2 in Fig. 1 are no longer equal, but have a net incremental difference. This net incremental difference is a function of the flow velocity v and is the basis of flow measurement by orifice plates.

Pulsative Flow. Now consider what measurements might be made on the medium when a pressure pulse wave is propagated in the medium simultaneously with smooth flow. Again several measurable changes occur. The particles are accelerated and as a result, are displaced from their smooth-flow positions.

The velocity at any point is no longer the smooth-flow value except at certain periods of time during a pulsation. This pulsative particle velocity will be denoted by the symbol u as it is the velocity due to the pulsation only, which is measured over and above any motion of the gas as a whole. Since in present-day use of orifice plates for gas flow measurements, pulsations are longitudinal, the direction of the vibratory motion of the particles is the same as the direction of propogation. Then, the total velocity will be $V \pm u$. It has been experimentally demonstrated[5] that when V is zero (smooth-flow zero) and u has a magnitude, (pulsations present) an orifice plate yields an indication of flow.

Since the orifice plate itself does not recognize direction, and it is eventually necessary to know the relation between the pipe or flange taps on the meter run, points A_1 and A_2 of Fig. 2, the next concept to inject into the theory is the *relationship of net flow direction with respect to the direction of pulse propagation*. Since the net flow velocity at any point in the system is the algebraic sum of the smooth-flow velocity

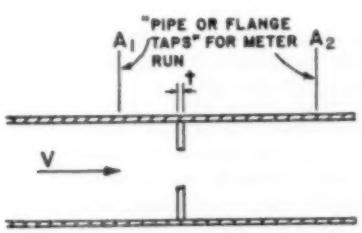


FIG. 1. **Orifice meter run** for smooth flow conditions.

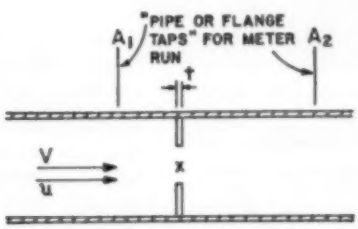


FIG. 2. **Orifice meter run** for simultaneous smooth flow and pulsative flow with propagation in the same direction.

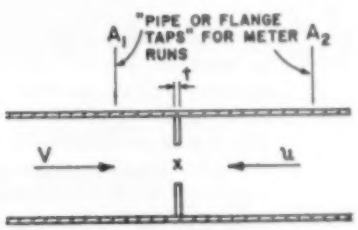
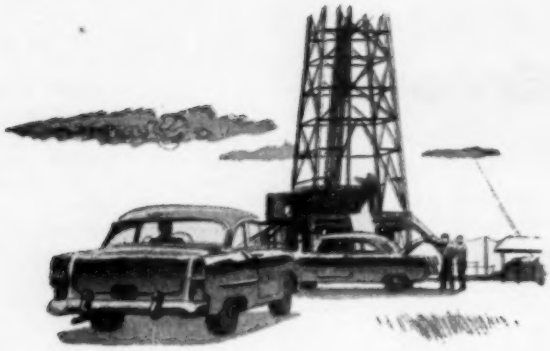


FIG. 3. **Orifice meter run** for simultaneous smooth flow and pulsative flow with propagation in opposite directions.



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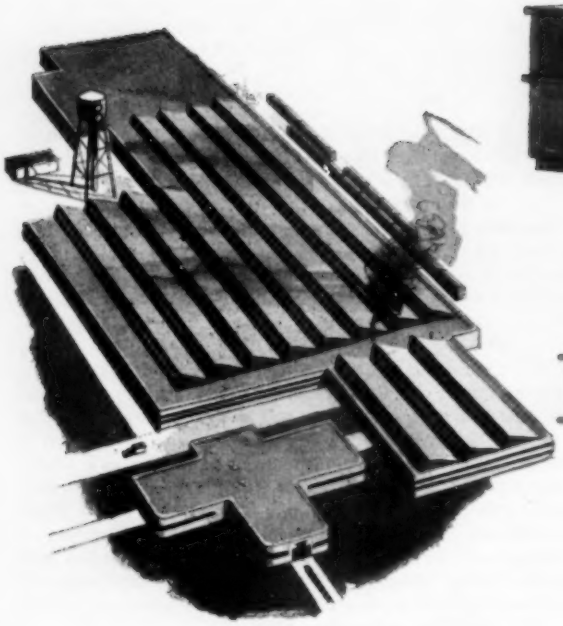

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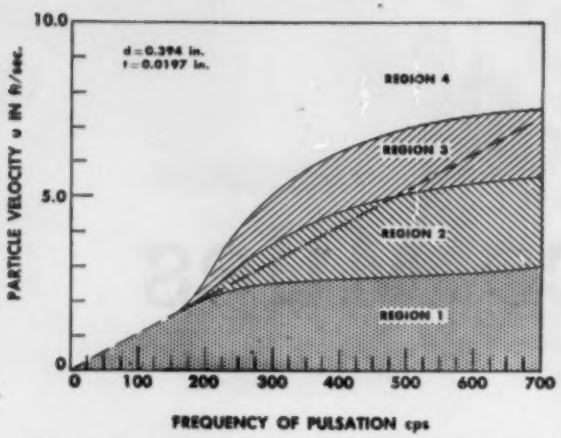

FIG. 4. **Phase diagram** of an aperture showing the regions of different types of circulations and turbulence (Ref.) Ingard.[7]

and the absolute magnitude of the particle velocity ($V \pm |u|$), $+|u|$ will be used when V and $|u|$ have the same direction of propagation and—$|u|$ when the pulse progagation is in a direction opposed to the smooth-flow velocity. In other words, the notation ($V + |u|$) means the smooth-flow and pulsative flow originate on the same side of the orifice plate while in the notation ($V - |u|$) the smooth-flow and pulsative-flow sources originate on opposite sides of the orifice plate.

Using Fig. 2, if the smooth-flow direction is from left to right and the source of pulsations is on the left, the direction and propagation of the pulse will be from left to right. This produces for smooth flow, velocity V_2 greater than V_1 and for pulsative velocity $|u_1|$ greater than $|u_2|$. Therefore, since both the smooth and pulsative sources are propagating these velocities in the same direction, the net velocity at A_1 will be ($V_1 + |u_1|$); and the net velocity ($V_2 + |u_2|$) at A_2, resulting in a velocity error at points A_1 and A_2 with respect to smooth-flow conditions because of the factor $|u|$.

When the smooth-flow direction is from left to right and the source of pulsations is at the right, the direction of propagation of the pulse will be from right to left. This produces, using Fig. 3, V_2 at A_2 greater than V_1 at A_1 for the smooth-flow velocity and $|u_2|$ at A_2 greater than $|u_1|$ at A_1 for the pulsative velocity. Therefore, the net velocity will be ($V_1 - |u_1|$) at point A_1 and ($V_2 - |u_2|$) at point A_2, which also produces a velocity error at each point (A_1 and A_2) by the factor $|u|$ with respect to smooth-flow velocity.

Velocity Errors. Since, with field techniques, the measurement of particle velocity is a difficult task, these velocities can be approximated by the measurement of the pulse pressure and computing of the particle velocity at the point of measurement. This is accomplished by the use of the equation[10].

$$|u| = 4637 \frac{|p|}{\rho v} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where $|u|$ = absolute root mean square value of particle velocity (ft per sec),
$|p|$ = absolute root mean square value of pulse pressure (lb per sq in.),
ρ = density (lb per cu ft), and
v = velocity of sound in the gas (ft per sec).

However, when it is desired to know the particle velocity at x in Fig. 2, which has no simple means of measurement, the pulse can be measured at the upstream side of the orifice plate with respect to the source of pulsations and then this particle velocity calculation can be corrected by the ratio of the orifice area (S_x) to measuring point area (S_{A_1}), i.e.

$$|u_x| = 4637 \frac{|p_{A_1}|}{\rho v} \frac{S_{A_1}}{S_x} \quad . \quad . \quad . \quad . \quad (2)$$

Thus, it can be seen that using Bernoulli's relationship which assumes no pulsations, one can calculate the net flow velocity through orifice plate, and with one measurement of the pulse pressure at the upstream static pressure point, for pulse propagation and net flow velocity in same direction, the particle velocity can be calculated and the velocity error can be determined at the measuring point or within the orifice plate. The orifice plate sees the sum of these velocities ($V_x + |u_x|$ and since it is basically a velocity device, its error is the ratio ($V_x \pm |u_x|$) $/V_x$. This essentially means that, irrespective of what is done to the secondary element with respect to damping or mathematical gyrations, this velocity error will always be present in systems that have pulsations.

Pressure-Drop Errors. Another method based on the particle velocity of a pulse that can be used to ascertain orifice plate errors was developed through the efforts of a group at MIT[6,7,8]. This group's work refined and added to L. J. Sivian's[9] work of 1935 on orifice plate reaction to pulsative flow. Ingard's [6,7] and Westervelt's[8] work developed the nonlinear relationships and some limits of applicability of these methods to orifice plate analysis for pulsative-flow conditions. The equation developed from Westervelt's[8] work, can be used to calculate the pressure differential across an orifice plate due to pulsative conditions:

$$|\Delta p| = 2318 \frac{\left(|p| \frac{S_{A_1}}{S_x}\right)^2}{\rho C^2 v^2} \quad . \quad . \quad . \quad . \quad (3)$$

where $|\Delta p|$ = absolute pressure differential (lb per sq in.),
$|p|$ = absolute magnitude of pulsation (lb per sq in.),
S_{A_1} = cross sectional flow area at measuring point (sq in.),
S_x = cross sectional area of orifice (sq in.),
ρ = density of gas (lb per cu ft),
C = orifice flow coefficient ($C_v\, C_c$),
v = velocity of sound in gas (ft per sec).

Since the pressure drop across the orifice is a function of the velocities through the plate, the error ratio is $\Delta p \pm |\Delta p|/\Delta P$.

Limitations. The first limitation is on both methods of calculation of orifice errors. This limitation is on the orifice plate maximum allowable thickness of the measuring section of the orifice plate. In order to visualize the region of applicability of this limitation, a sketch of one of Ingard's phase diagrams is shown in Fig. 4 to demonstrate the various regions: Region 1 and 2 are two types of laminar acoustic streaming; region 3, turbulent motion around the orifice; region 4, where an acoustic jet is formed. Region 4 is the area is which the equations are applicable and the particle-velocity amplitude of the pulsation seems to be the important factor. A critical orifice plate thickness t_c for this region can be defined. This thickness t_c is a function of the particle velocity and frequency of pulsa-

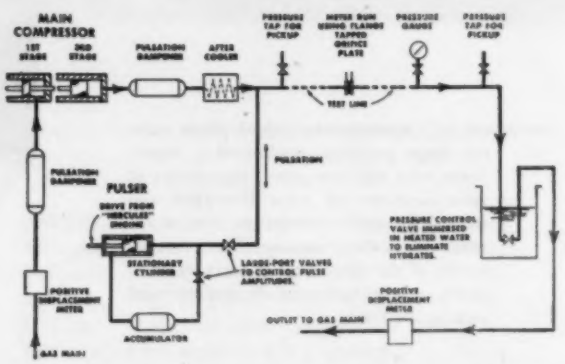

FIG. 5. **Pulsative flow tests** on an orifice plate were made in a laboratory installation as shown by this flow diagram.

tion, and equals the displacement s of the particle due to pulsation. Correspondingly, a critical thickness can be defined as $t_c = s = |u|/2\pi f$, where $|u|$ is the particle velocity due to pulsations and f is frequency of pulsations. Since the orifice plate thickness t is normally less than t_c in gas transporting systems, which use reciprocating compressors, region four of Fig. 4 is normally involved.

The second limitation is with respect to the use of equation (3), which is for pressure drop due to pulsations. This limitation applies to the position of the pulsation source with respect to the direction of net flow and the position of points A_1 and A_2 of Fig. 2 and 3. When operating under conditions as set forth for Fig. 2, there are no limitations as both pulse propagation and net flow are in the same direction with respect to points A_1 and A_2. When operating under conditions as set forth for Fig. 3, there seems to be a possibility of a correction factor necessary to correct for the difference in position of A_1 and A_2 with respect to pulse propagation and net flow direction.

The third limitation is with respect to the use of electrical analogies in the analysis of orifice plate problems. This point bears upon the linearity requirement of resistance and reactance. In electrical analysis, these quantities are linear; and when used as analogies, it is assumed the items they represent are linear. Using the work of Ingard and Westervelt on orifice plates, they can be shown to be non-linear in the region of practical gas transmission where reciprocating-type compressors are used. Therefore, a re-evaluation of the analogy is necessary to account for this nonlinearity.

Application of Velocity Error

In order to show the application of the velocity error theory to orifice plate installations, data are presented from laboratory tests and field installations. A generalized flow diagram

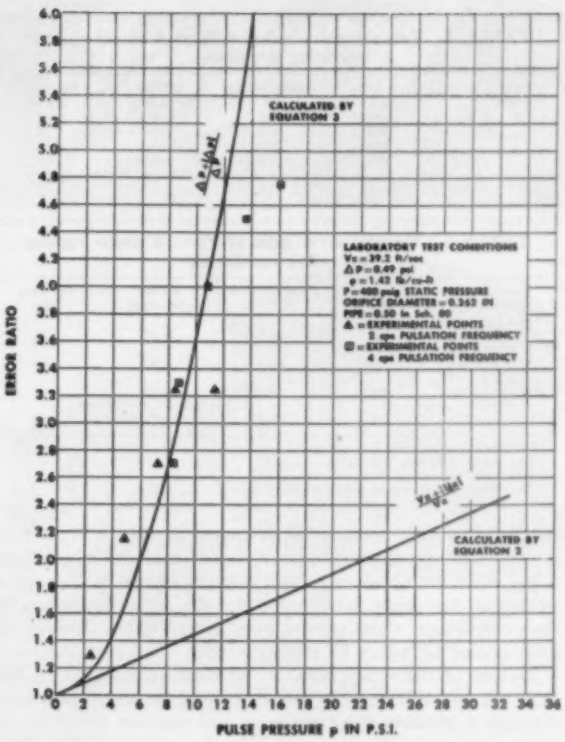
ERROR RATIO
PULSE PRESSURE p IN P.S.I.
CALCULATED BY EQUATION 3
CALCULATED BY EQUATION 2
LABORATORY TEST CONDITIONS
ORIFICE DIAMETER = 0.365 IN
PIPE = 0.50 In Sch. 80
Δ = EXPERIMENTAL POINTS
2 cps PULSATION FREQUENCY
□ = EXPERIMENTAL POINTS
4 cps PULSATION FREQUENCY

FIG. 6. **Velocity error** and differential-pressure error ratio vs amplitude of pulsation.

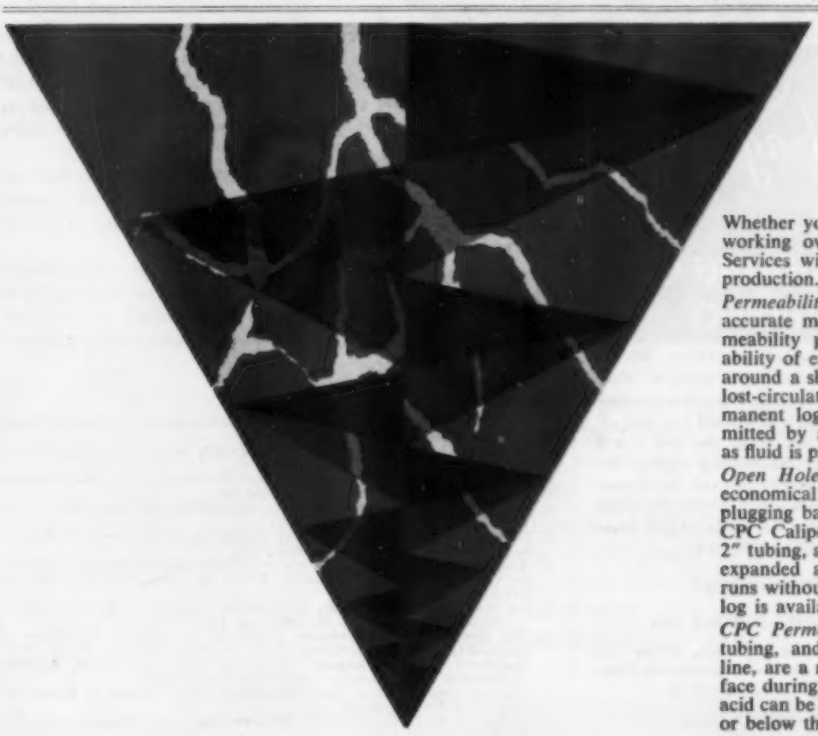

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TABLE 1. Velocity error ratio of Plant A under various operating conditions.

Engines in operation	Stat. press. psig	Flow vel. ft/sec Vx	p Pulse press. (psi)	Vel. error ratio
1, 2, 3, 4, 5, & 6	900	32.3	1.40	1.09
1, 3, & 5	900	16.8	1.19	1.14
1	900	8.8	0.74	1.26
3	900	6.0	1.19	1.38

Orifice diameter = 6.500 in.
Orifice meter run = 12 in. Nom. Sch. 80

TABLE 2. Velocity error ratio of Plant B under various operating conditions.

Engines in operation	Stat. press. psig	Flow vel. ft/sec Vx	p Pulse press. (psi)	Vel. error ratio
1 & 2 D.A. discharge	624	61.2	0.61	1.03
1 & 2 D.A. suction	540	89.0	2.60	1.06
1 & 2 S.A. discharge	895	23.3*	10.00	1.92
1 & 2 S.A. suction	590	86.0	8.15	1.16

Discharge orifice diameter = 4.500 in.
Suction orifice diameter = 6.000 in.
Orifice meter run = 8 in. Nom. Sch. 80
* Two meter runs were used and flow was split.

of the laboratory installation is shown in Fig. 5. This flow system takes gas through a positive displacement meter from a gas main, compresses it and then discharges it through a pulsation dampener, which removes the pulse developed by the compressor. Flow is now smooth and is fed through an after-cooler to reduce its temperature.

Output of the after-cooler is fed through a length of line that has an orifice meter run as part of its length and then through a pressure-reducing valve and positive displacement meter back into the gas main. At the output of the after-cooler, controlled pulsations are fed into the system from a pulser that controls the frequency and magnitude of the injected pulse. The meter-run line size was 0.5-in. schedule 80 pipe and the orifice plate thickness at the measuring point was 0.02 in. thick. This gave, for the pipe and orifice diameters used, beta ratios of 0.30, 0.37, 0.48 to 0.58.

The theoretical velocity error ratio and pressure-differential error ratio for a typical operating condition of the laboratory system is shown in Fig. 6 with experimental data plotted for the pressure-differential error ratio. This graph shows the velocity error ratio within the orifice place, point x of Fig. 2, and the pressure-differential error ratio between A_1 and A_2 of Fig 2 for pulsative flow conditions on the same orifice plate with varying amplitude of pulsations.

Plant A and B, shown in Tables 1 and 2 respectively, are field installations used for gas storage or transmission, and tests were run on both plants to determine orifice meter errors. Plant A was composed of six reciprocating compressors that could be connected to pump into or out of storage. Tests on this plant were conducted when the compressors were pumping into storage; therefore, the meter was used to measure the suction flow rate. Since basically the velocity error at point x Fig. 2 does not recognize direction, the error is tabulated in Table 1 as a ratio with no indication of direction.

Plant B was composed of two reciprocating compressors that were connected in parallel across a suction and discharge header. Each header system had its own meter run; therefore, simultaneous readings could be taken at both orifice plates. Since the compressors were able to operate both single acting (SA) and double acting (DA), a relationship between these two conditions was obtained. However, during the single-acting condition, it was required to by-pass some gas through another meter system, thereby lowering the flow velocity through the orifice plate, which caused an exceptionally high velocity error ratio. This error is tabulated in Table 2.

Summary

Two concepts have been presented, the first being the velocity error caused by the combination of pulsative velocity and smooth-flow velocity through the orifice plate. This concept is a linear function $u\alpha(p)$. Field data are given to demonstrate the magnitude this velocity error can attain under pulsative-flow conditions.

The second concept is the pressure differential between points A_1, A_2 in Fig. 2 caused by the pulsative velocity through the orifice plate. This concept is a non-linear function $\Delta p\alpha(p)^2$.

Equations are given for the computations of both pulsative velocity and differential pressure. These equations apply to region four of Ingard's phase diagrams, which are normally the conditions of pulsative flow in gas transmission plants or refineries.

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Acknowledgment

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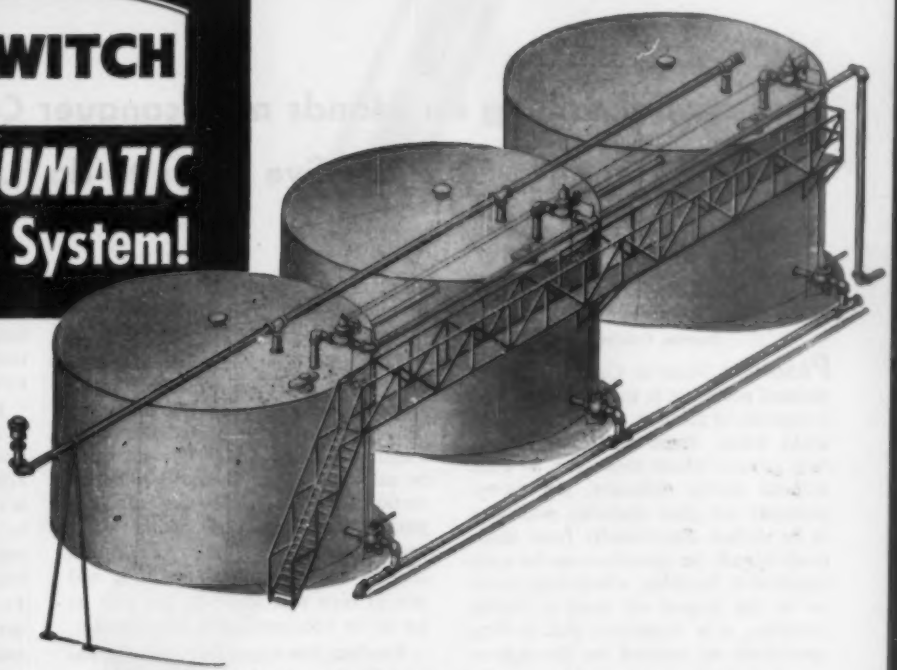

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Is This the Answer to Pembina Drilling Problems?

Directional drilling on islands may conquer Canadian muskeg. Here are five ways to do it.

H. John Eastman,
President, Eastman Oil Well Survey Company, Denver, Colorado

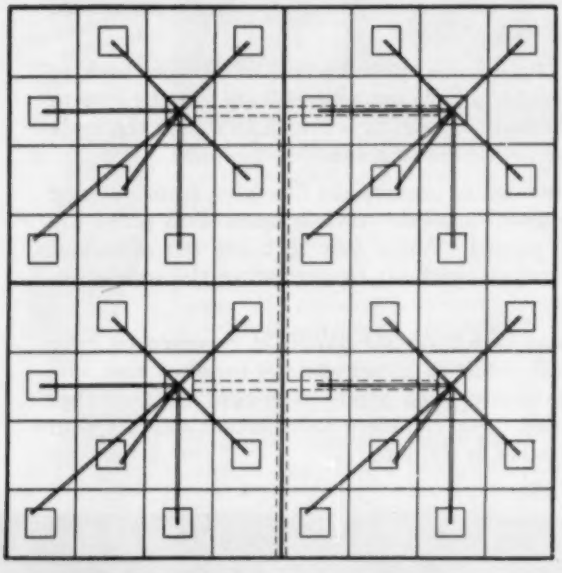
PEMBINA Field in Canada presents unusual problems in the drilling for oil. It consists of muskeg, rivers, forest and small lakes. Some locations are on firm ground where roads can be built without undue difficulty, but many, probably the great majority, will have to be drilled directionally from man-made islands. In operations on the scale required in Pembina, which may prove to be the largest oil field in North America, it is important that drilling operations be carried on throughout the year. Access to well heads will be required at all times. Cost of roads and of islands will be high.

The program finally adopted to drill the larger leases will undoubtedly be a compromise between minimum expense on roads and islands, and the maximum number of wells which can be economically and safely drilled directionally from one central site. Important additional advantages of a central site will be the concentration and shortening of collecting lines, and this in turn will result in less cost as far as the wax problem is concerned.

Pembina has many features of a major problem, although fortunately the drilling itself should be easy. Eastman has made proposals on how the area could be drilled with 8 to 12 wells from each island.

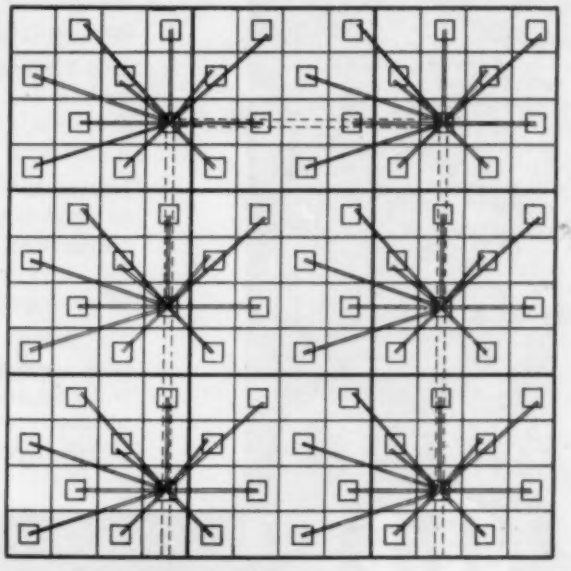
In the past 25 years, Eastman's work in directional drilling has been in various sections of the world. A typical application of directional drilling that is very similar to the situation that will be encountered in the Pembina field is one that Eastman engineers did in Europe on the Dutch-German border. That area is a peat moss area, and naturally the individual cost of surface locations would have been prohibitive.

FIG. 1. Proposal No. 1, 4 sections, 2660 acres.



32 wells from 4 island sites
1 straight hole per section
3.635 miles of road, or 0.113 mile per well
Maximum deviation 3120 ft, maximum angle 39° 32'
Additional footage for directional wells—2785 ft per section.

FIG. 2. Proposal No. 2, 9 sections, 5760 acres.



72 wells from 6 island sites
2 straight holes per 3 sections
6¼ miles of roads, or 0.087 mile per well
Maximum deviation 3630 ft, maximum angle 44° 45'
Additional footage for directional wells—4778 ft per section.

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YOU KNOW that one of the best ways to reduce cost per foot of hole is to boost rate of penetration. And one of the best ways to boost rate of penetration is to stabilize your string against shock loads and lateral movement of the drill collars or pipe.

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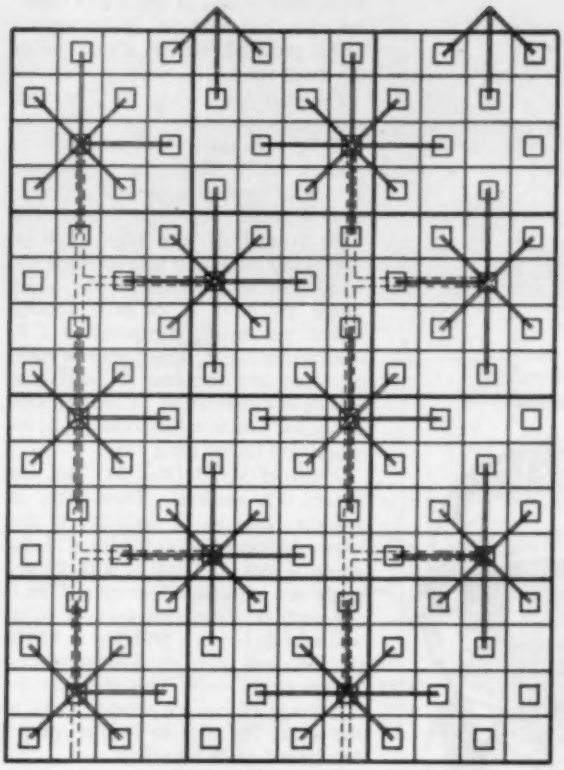
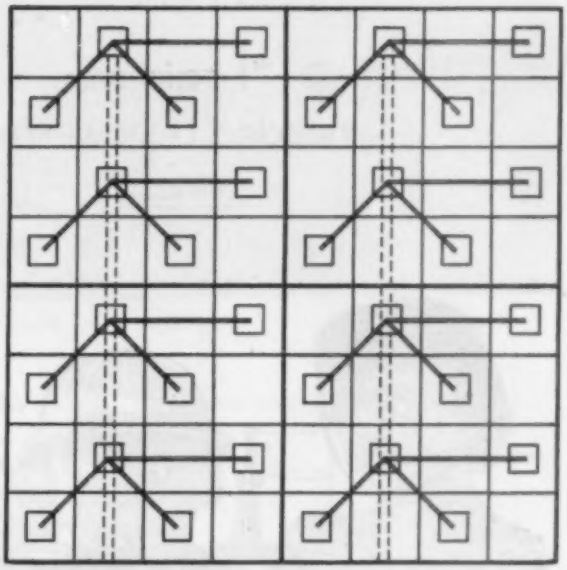
NEW MEXICO—Hobbs—Phone 3-6211
CANADA—Edmonton—Phone 25-2232
EXPORT—New York City—Phone Hanover 2-2455

FIG. 3. Proposal No. 3, 12 sections, 7680 acres.



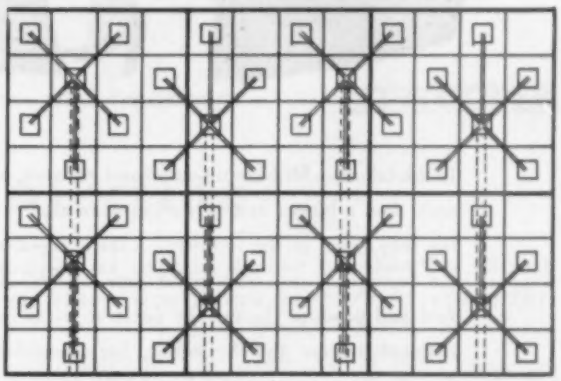
9 miles of roads to serve a maximum of 96 wells, or 0.1 mile per well
10 straight holes in 12 sections
Maximum deviation 2190 ft, maximum angle 28° 3'
Additional footage for directional wells—2796 ft per section.

FIG. 4. Proposal No. 4, 4 sections, 2660 acres.



Unit of 1 section
8 wells from 2 island sites
2 straight holes per section
1 mile of road per 8 wells, or 0.125 mile per well
Maximum deviation 2190 ft, maximum angle 28° 34'
Additional footage for directional wells—1730 ft per section.

FIG. 5. Proposal No. 5, 6 sections, 3840 acres.



48 wells from 8 island sites
8 straight holes
1/8 of a mile road per well
Maximum deviation 2190 ft, maximum angle 28° 34'
Additional footage for directional wells—1596 ft per section.

It was also necessary there to build roads and islands for the rig structures.

In directional drilling from island locations there are these basic advantages:

1. Only one site needs to be cleared on each section, instead of eight in order to drill eight wells.
2. Rig moves are considerably shorter.
3. Pipe and tool racks can be centralized.
4. Centralization reduces the amount of drilling mud necessary.
5. Considerable reduction in the length of flow lines contributes toward simplification of the wax problem.
6. Batteries of storage tanks can be installed more economically in relation to well heads.

The total value of these advantages and economies will vary. They will, however, help compensate for the additional cost of the directionally drilled wells. After considerable study of the area, the Eastman Company has the following proposals to offer for the drilling of the Pembina field. *Proposal* No. 1 (Fig. 1.) This shows an area of 4 sections with 32 wells from 4 island sites. There is one straight hole per section. There is one kick of 3100 ft with a 40 deg angle and extra footage of 1000 ft. There are 2 kicks of 2100 ft with a maximum angle of 28 deg with an extra footage of 533 ft. There are 4 kicks of 1200 ft with maximum angle of 16 deg. The total extra footage is

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2785 ft per section of land. We have estimated the cost of roads and islands for this proposal at approximately $1900 per well, and all islands are on the main road.

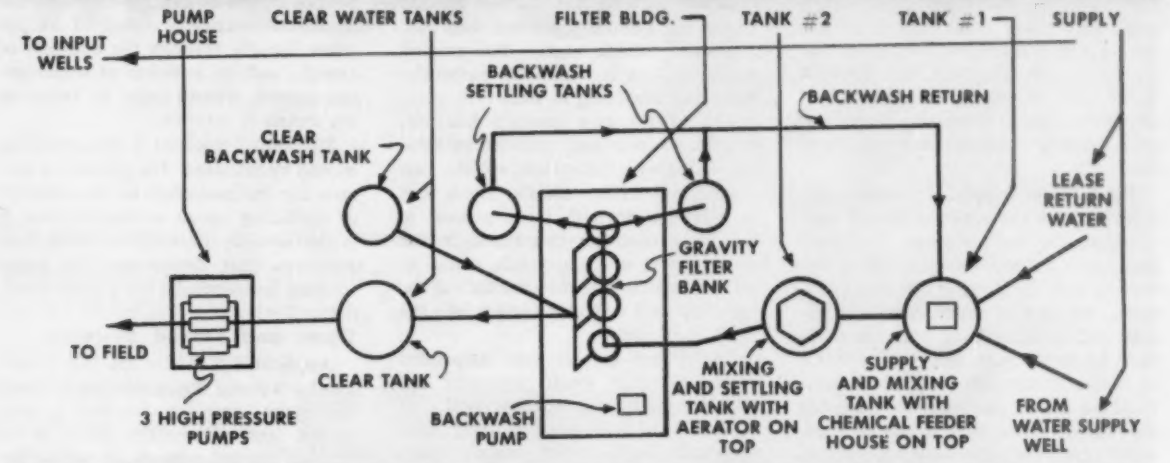
Proposal No. 2 (Fig. 2). There are nine sections shown in this proposal with 72 wells on 6 island sites with an average of ⅔ of a straight hole per section of land, 4 holes with a kick of 1200 ft and 15 deg angle, 3 holes with 2100 ft and 28 deg angle, 2 holes with 3100 ft and 40 deg angle, and 2 holes with 3600 ft and 44 deg angle. There are 4778 ft of extra footage in this per section compared to 2785 in Proposal No. 1. There are 6¼ miles of roads and the cost of roads and islands is estimated at $1200 per well, as against $1900 in Proposal No. 1. All islands are on the main road.

Proposal No. 3 (Fig. 3). This one covers 12 sections. There are 10 straight holes in 12 sections. It also shows 4 kicks of 1200 ft with a 15 deg angle, 4 kicks of 2100 ft with 29 deg angle and additional footage is 2796 ft per section. Estimated cost of roads and islands for this proposal is $1620 per well, and there are 9 miles of road to service 96 wells. This plan has the advantage of having shorter kicks to the wells. The sites do require quite a few lateral roads into them.

Proposal No. 4 (Fig. 4). This is a 4 section group and there are 8 wells per section from 2 island sites per section. Note, also, that there are 2 straight holes per section which is the highest number. There are 2 kicks of 2100 ft with a 29 deg angle, extra footage of 166 per well. There are 4 kicks of 1200 ft with a 15 deg maximum angle and 533 extra ft per well. There is one mile of road per section and additional footage is 1730 ft per section. The estimated cost of roads and islands in this proposal is $3225.

Proposal No. 5 (Fig. 5). This covers 6 sections with 48 wells drilled from 8 island sites, an average of 6 wells per island. Eight straight holes are in these six sections. There are 4 kicks of 1200 ft with a 10 deg angle, extra footage of 166 ft per well. There is one kick of 2190 ft with 28 deg, and 533 ft per well extra footage. The total extra footage in this proposal is 1596 ft per section. A ⅛ of a mile of road per well would have to be built, and the estimated cost of the roads and islands is $2391 per well.

This discussion and the proposals show advantages of a directional drilling program as compared to straight hole drilling in a muskeg area. The savings in other phases of the entire field operation and increased operating efficiency would also tend to recommend that a directional drilling program be tried in the Pembina field. ★



Open-type water treating plant shown in photo above located on hillside to take advantage of gravity flow. In flow diagram of this plant. Note mixing and sedimentation functions are accomplished in stave tanks rather than in ponds.

P 538.

Part 7 | **Injection water, its source, problems and treatment** **EXCLUSIVE**

Elements of Water Injection

An adequate supply of usable water is essential to any injection project. Here are some factors to consider.

J. Randolph Buck
McCoy and Buck, Petroleum Consultants
Dallas, Texas

BASIC requirements for injection water are: (1) Available in adequate quantities as needed, (2) free from silt or other suspended material, and (3) chemically stable and inactive with respect to compounds and elements present in the reservoir. Water supply systems range in complexity from the exceedingly simple for good-quality water to elaborate installations as required for processing gaseous, contaminated and certain mineralized waters.

To approximate the total quantity of water required to flood a given property, simply multiply the reservoir pore volume in barrels by 1½. Roughly half of this quantity will be available as produced water while the other half must be supplied to the project from an outside source. This is a rule-of-thumb method only, and more substantial predictions are calculated from data applicable to specific operations.

Source of Injection Water

In almost all areas, at least one source of injection water can be developed. Many areas offer a choice. Surface supplies can be obtained from lakes and rivers. These are usually high in oxygen content, carry much suspended material and bacteria, and show wide variations in composition depending on the amount of rainfall and river stages. Immediately below the surface in river bottoms there are often gravel beds fed from the river. These supplies are quite excellent, usually non-corrosive, quite reliable even if the river dries up for a period and are naturally filtered. In some coastal regions, naturally filtered ocean water can be obtained below the ocean floor. Subsurface supplies of either fresh water or brine or both can usually be tapped by wells to various depths. It is not always the shallowest water sand that is the most favorable.

An assured deep supply is preferred to a shallow source of uncertain productivity. In many cases, high liquid levels that result from opening a deep, prolific sand permit lower water lifting costs than for the shallow sand which requires a high liquid level drawdown.

Supply Pumps. Water supply wells are produced by centrifugal, submersible, turbine rod pumps or by gas lift, depending on volumes required and liquid levels. Pumps and water supplies may fail on occasion, yet floods should continue when once started. Provisions are made for spare pumps or an emergency water supply for use during any foreseeable failures in the regular system. The peak rate at which water shall be delivered can be reasonably estimated from the number and performance characteristics of injection wells.

Fresh Water Supply. If surface water is to be used, the regional drouth situation should be reviewed. Not very long ago, a flood was shut down for two months in Rogers County, Oklahoma, for lack of water. Southern Illinois and Indiana have been similarly hard hit in the past. Water over much of Texas is certainly in short supply. In these cases, an operator choosing the use of brine over available fresh water is not only choosing wisely from the technical point of view, but also is aiding the conservation of a vital natural resource. One can visualize a possible future necessity for state authorities to prohibit the injection of fresh water into oil reservoirs when fresh water regionally is in short supply.

Problems and Treatment

Four Types of Impurities. Probably the simplest system consists of a pump to lift water from the supply directly into the injection well. This is rarely practical because of water quality. Water can be poor on four major counts.

(1) Water can contain the acid gases carbon dioxide and hydrogen sulfide and/or oxygen. The problem is largely corrosion. Of the three gases, oxygen is the worst offender. It causes rapid pitting of iron pipe and clogging of injection wells with rust. Carbon dioxide creates hard black scales and deep pits. Hydrogen sulfide causes fine-grained scales, shallow indentations, embrittlement and blistering in steel.

(2) Water can contain barium, strontium, iron and calcium in solution along with the sulfate, sulfide, corbonate and oxide radicals. These ions in combination with those present in the flood reservoir can result in the precipitation of compounds, some insoluble, which plug the sand face at the injection well and also farther into the sand body itself.

(3) Water can contain suspended material, which would promptly and effectively plug the injection well.

(4) Water can contain algae, bacteria and other micro-organisms, which grow in the reservoir environment to the extent of choking the injection well. Some bacteria generate corrosive hydrogen sulfide.

Impurities Controlled. Fortunately, it is necessary only to recognize and control the above four harmful water qualities. They need not be eliminated. Because all waters differ in the degree of contamination by these factors, the water treatment plant for each flood differs from those previously designed for other floods.

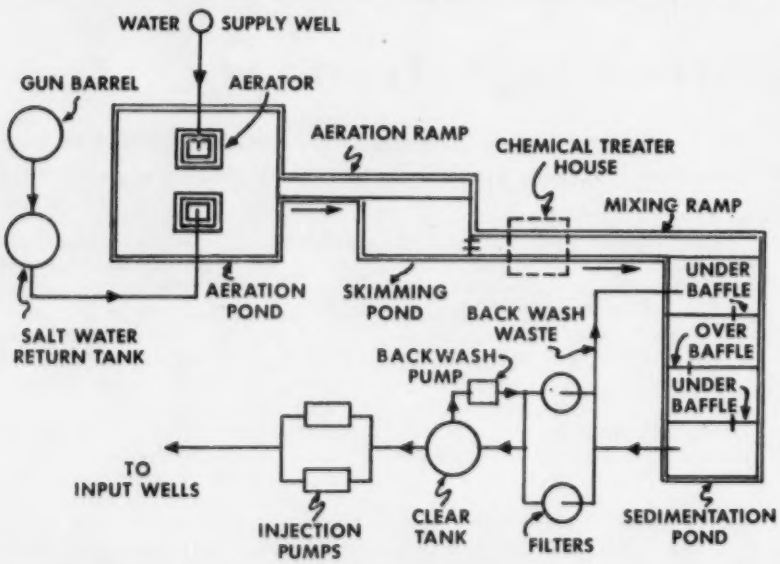
Dissolved gases can be removed through aeration or specialized packed tower eqiupment. The alternative is to use chemical corrosion inhibitors, which typically perform their function by forming a film over metal surfaces and thereby slowing the corrosive action. Precipitation of metallic compounds can be minimized through care in water selection, control of its pH value, usually through the addition of caustic, and by addition of sequestering agents, which assist in retaining the metals in solution.

Suspended material is effectively removed by filtration. The growth of bacteria can be controlled by the addition of sterilizing agents or bactericides. It is the severity of each of these four problems that determines the water treating requirements for a given flood.

Open and Closed Systems

Applicability. There are two fundamental types of water treating systems. One is the "open" system, that is, open to the atmosphere. The other is the "closed" system, wherein all contact between supply water and air is avoided. When the supply water is highly supersaturated or undersaturated with carbonate, and hence requires stabilization, and for the cases where dissolved gas, iron or manganese should be removed, the open system is used. When the supply and reservoir water are stable and compatible and when the problem is one of filtration, sequestration and sterilization, then the closed system is safely used. The closed system requires a lower initial investment, so is preferred even when the issue is in doubt. In the event of failure of a closed system on early tests, it can be expanded into an open type with small loss in initial investment and before severe damage to the input well system has been incurred.

Stabilization and Sedimentation. In the open system, water from the primary supply and from the gun barrel is fed into the settling pond through an aerator and skimming pond. Ferrous compounds are oxidized into the insoluble ferric form, which precipitates out of the water. Manganese is similarly converted. Dissolved gases are liberated, the pH value rises and carbonate supersaturation of the water is reduced. To hasten the settling process, a coagulant such as alum is added. Alum combines with bicarbonates in the water to form aluminum hydroxide, which precipitates and tends to trap



Detention ponds are employed in the open-type water treating plant described in this flow diagram.

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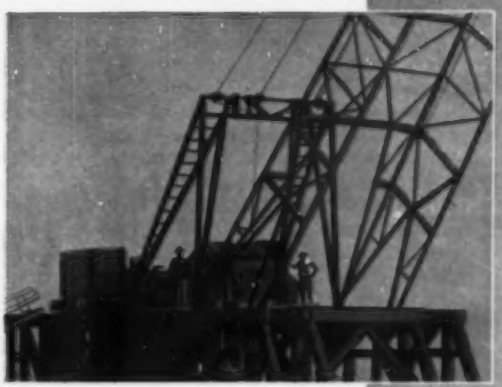

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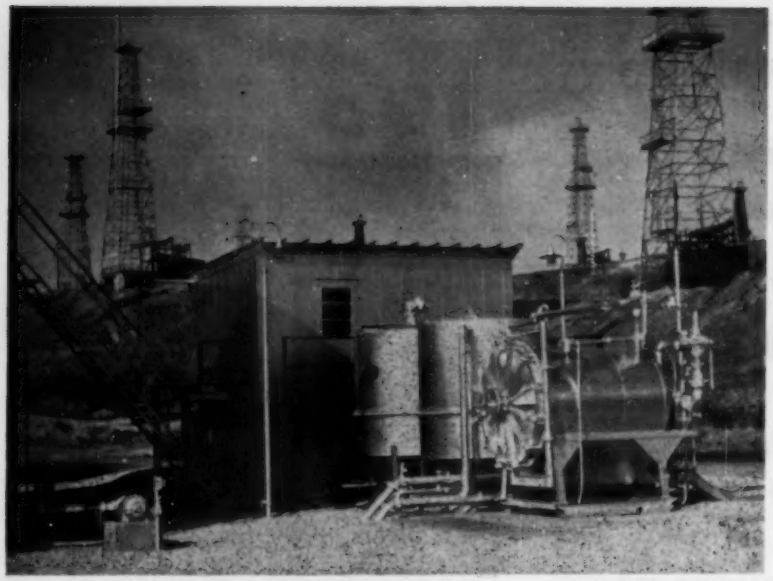


Element-type filter plant. Horizontal tank in foreground is the filter unit wherein water is forced through coated screens. Precoat and slurry tanks are immediately behind this filter tank.

other suspended solids. Ferric chloride rather than alum is used as a coagulant when barium is present, as in the Arbuckle water of some localities. Effective coagulation reduces the size of the sedimentation pond required for a given water throughput. An alkali, usually lime, may be added in controlled quantities to react with free carbon dioxide and bicarbonates to form carbonate precipitates, and thereby stabilizes the water. Frequently, it has been found satisfactory to maintain a carbonate supersaturation of 10 to 15 parts per million. Chemicals are customarily mixed with the water at some point between the aerator and the sedimentation pond. The sedimentation pond, through proper sizing, the effective use of chemicals, and the strategic placement of baffles, detains the water long enough for most of the suspended solids to settle out. While the use of retention ponds characterizes many treating plant installations, certain functions of these ponds are in other cases carried out more compactly through the use of "rapid reactors" or "accelerators" that are of the tank-type design.

Filters. The water progresses to the filters to finish the job not completed in the pond. While rapid or pressure filters are the more common, the filter material may be placed in open tanks with gravity flow through it. Typically, the filter is packed with layers of crushed rock, gravel and sand. Crushed anthracite coal may be substituted for the sand and is preferred particularly when the treated water contains some oil droplets carried over from the gun barrel. Sand, when contaminated with oil, must be discarded or else given a special cleansing treatment, as with hot caustic.

The element-type filter is quite different from the usual filter pack described above. In this design, replacable or self-cleaning filter disks are coated with asbestos fiber, diatomaceous earth or other materials. Coating is accomplished in the field by circulating a slurry containing the filter media through the disk screens. Element-type filters are compact, efficient and easy to maintain.

Cleaning the Filters. Filters become plugged, lose their efficiency, and require backwashing to remove the deposited residue. Normally, water proceeds from the filters to the clear tank, where it is held for injection into the reservoir by gravity or by injection pumps. Backflushing is the process of reversing the direction of flow by pumping water from the clear tank back up through the filter and discharging into a backwash pond or to the sedimentation pond. If water is forced through the filter at about five times the usual filtering rate, then the sand beds will be sufficiently agitated to resort and clean themselves. Centrifugal pumps provide good control features for backwash service.

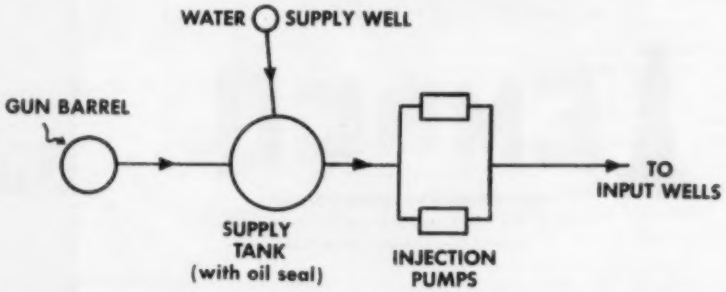
Element-type filters are readily cleaned in the field either by changing disks or by removing sludge from the disks through the use of design features specifically provided with this type equipment, such as internal hydraulic jet action.

Filter Capacity. Filter total capacity can be roughly estimated on the basis of about 3 gpm per square foot of filter area. The filtered water for injection should show less than 10 parts per million of suspended solids. If the water entering the filter exceeds about five times this turbidity, then the filter will be overloaded and will require too frequent backwashing. The need for improved sedimentation facilities would be indicated.

Clear Tanks. The clear tank is for temporary storage only. Although not always practiced, it is desirable to have a several-hour supply to last during the shut-down of any portion of the treating system. Wooden tanks or cement-lined pits are particularly suitable for clear water storage.

Chemicals. Specialized chemicals are added to the water as required before sedimentation or after filtration. Formaldehyde, polyphosphate and quarternary ammonium compounds are among the corrosion inhibitors. Sequestration with complex phosphates is designed to keep iron and carbonates in solution, provided that reservoir or water temperature is not too high. Chlorine, copper sulfate or calcium hypochlorite are germicides that control bacteria, slime, molds and such organic growths. Certain of the quarternary ammonium salts acts as both corrosion inhibitor and germicide.

Deaeration. The use of a vacuum de-



Closed-type water supply system shown schematically. Air is eliminated, thereby minimizing treatment and size of plant.

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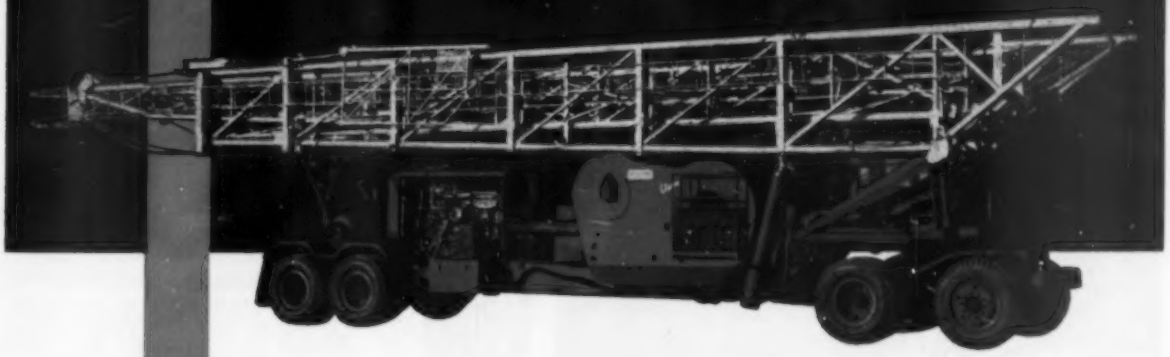

. . . THE MOST COMPLETE AND STREAMLINED WELL SERVICING UNIT

The Franks Clipper is a unit basically built for servicing — the main job of the unit — but which is also self propelled, using the drawworks motor for road power.

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WELL SERVICING AND DRILLING UNITS
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"ON THE SPOT" FIELD SERVICE

A DIVISION OF CABOT SHOPS, INC.

aerator to remove oxygen admitted to the water in the open-type system is in less favor now than was formerly the case. It is debatable whether the amount of good accomplished justifies the considerable expense to the system. Sodium sulfite can be used to remove the last trace of oxygen. (Oxygen also may be stripped from water by using a packed tower and injecting natural gas.)

Closed Systems. The closed system of water treatment incorporates direct connections from the supply well and gun barrel to a supply tank that is kept sealed from air exposure with a layer of oil on top or else with an atmosphere of natural or inert gas. Injection pumps may pick up the water directly from the supply tank or after filtration and chemical treatment for other than sedimentation. The simplicity of closed systems is apparent.

General Considerations

Water treatment is specialized work. When water of poor quality is all that is available, it is only reasonable to take all possible precautions to make it suitable for waterflood purposes. On the other hand, the over-treatment of water is an economic burden to the flood. Mixing fresh waters and brines is not so critical a matter as is generally believed. The wide variations in water compositions that have been successfully mixed without treatment is evidence of this point. Large numbers of closed-system plants are in regular use today. Evidence that indicates the necessity for the higher-cost open system should be very convincing in order to swing the decision in that direction

Plant Design. A little advance planning in the layout and design features of a treating plant will payout in reduced operating and maintenance costs later on. Straight pipe runs will permit the use of ordinary pipe cleaners. Flanged connections resist corrosion better than threaded joints. Seamless pipe will survive longer than lap or continuous weld. Keeping the water lines above ground for frequent inspection and servicing is good practice, weather permitting.

The choice of materials is important. The use of asbestos, cement-lined pipe, plastic liners, insulating coatings, or alloy metals are decided along with the water treatment methods.

In some cases, corrosion costs may be cheaper than its prevention. In general, coatings are successful only where some corrosion is acceptable. All coatings must be assumed to have certain leaks or breaks. In brines, electrolytic corrosion may be severe at the junction of dissimilar metals. Insulating gaskets minimize this situation. The entire plant is arranged with respect to local terrain to use gavity as much as possible (eliminating pumps), keeping pipe runs as short as possible, yet locating ponds and tanks where available space and appropriate subsoil coincide.

Personnel. It is practical for a competent field superintendent to keep abreast of the water plant operation. With the help of explicit instructions and a little equipment, he can run the daily tests for such as carbonate stability, pH value and corrosive gases and also the occasional iron test. He can help with corrosion observations using test coupons or rods inserted in the system at selected points. Periodic checks and assistance by specialists will be required, however.

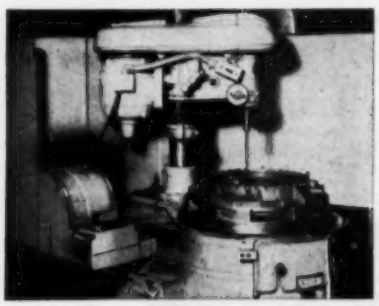
Summary. The water supply and treatment plant is an integral part of the waterflood project. It should be designed and operated with care. The simplest system that will be effective will bring both investment and operating economies to the project.

Part 8 considers the field operation of a water injection system. Discussed are some of the many field activities that help keep the flood going at top efficiency. Specific topics are: Input well behavior, water shut-off, unique innovations, cross flooding, and water-oil ratios.

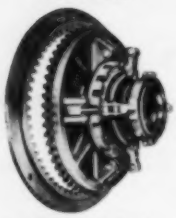
ROCKFORD

MEMO— Clutch must have accurate balance

All ROCKFORD clutch plates not only are carefully checked for accuracy of dimensions, but are inspected on an electronic balancing machine. Uniform operation, minimum wear,



OVER



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CLUTCHES

CAREFUL MEASUREMENT AND INSPECTION of every joint of drill pipe and every tool run in the hole is essential in accurately locating fish and conducting fishing operations.

FISHING IS SERIOUS BUSINESS as reflected in the faces of those in charge. Regular driller takes over at controls to give fishing expert G. J. Murphy, at left, a brief respite. Murphy and Carter Foreman, J. L. "Buddy" Greene, watch intently at weight indicator and pressure gage to determine how washover shoe is cutting.

P 428.3

fishing isn't fun

Carter Saves Mississippi Deep Well After 99-Day Fishing Job

RECORDS OF TOOLS AND PIPE run in the hole are carefully studied by Foreman Greene during progress of fishing job.

ABOUT one out of every 10 wells drilled last year required a fishing job. Here's an account of determination against overwhelming odds of just one of those jobs to "make a well."

Two twist-offs, drill pipe stuck four times, a caving hole and high-pressure sour gas made up the odds that The Carter Oil Company licked to successfully complete a 12,378-ft well north of Jackson, Mississippi. The battle lasted 99 hectic days (almost half the time from start to finish) and cost an estimated $170,000—considerably less than the cost of drilling a duplicate well.

The No. 1 X Cage-Sutherland was spudded in on February 5, 1955. Soft formations below the surface made drilling rather easy, for in just 12 days, the bit had penetrated to 5000 ft. By April 1, the well was down to 11,000 ft and making 90 to 100 ft a day in hard sandstone and shale.

First sign of trouble was encountered on April 6th when the drill pipe twisted off 1300 ft down the hole. The pipe itself was stuck at 10,000 ft, and pumping oil around the stuck pipe didn't help.

The drilling contractor fished for 30 days before reaching 11,144 ft. At this point, fishing ceased, and the hole was plugged with cement back to 10,700 ft. Cement was drilled out to 10,987 ft, and by whipstocking, the stuck pipe and bit in the cemented hole was bypassed. That was May 9th.

Three days later, the drill pipe became stuck again. Mud acid pumped down the hole ate away some of the binding rock formation around the bit. Washover pipe finished the job of freeing the stuck pipe the next day.

In another month, the hole had been drilled to 12,378 ft. Drill pipe stuck again at this depth as preparations were being made to run an electric log. Because the contractor had completed the hole to total depth required, this third fishing job was at Carter's expense.

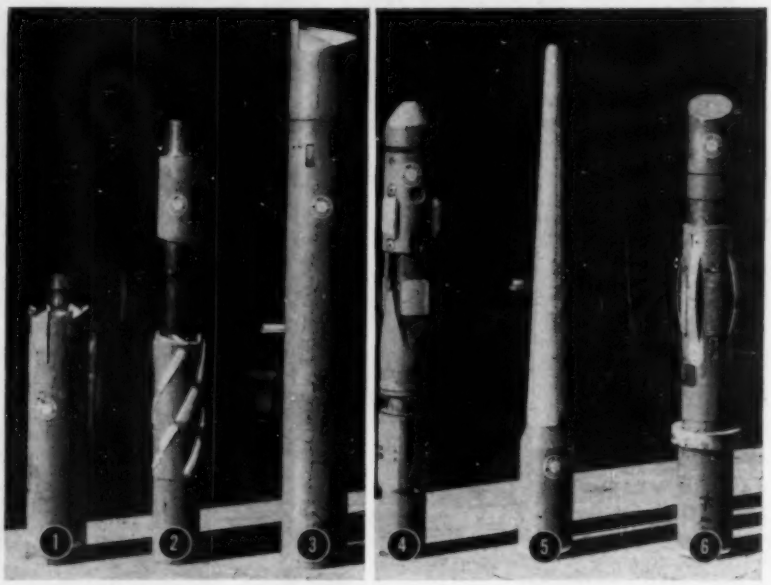
After running a free point indicator to locate where the pipe was stuck, the drill pipe was backed off at 10,717 ft. To effect this, a string shot consisting of an explosive charge was lowered into the well on a wire line and detonated opposite the point where two joints of pipe were made up. The explosion jarred the pipe at the shot point and the reverse torque or twist spun it free.

Carter called in fishing experts from Shreveport, Louisiana, Houston, Texas, and other points for the work. Fishing time, tool rental, air freight and hot-shot truck hauls added up to nearly $40,000 before the job was done. Rig costs ran as high as $1100 a day, depending upon the fishing depth.

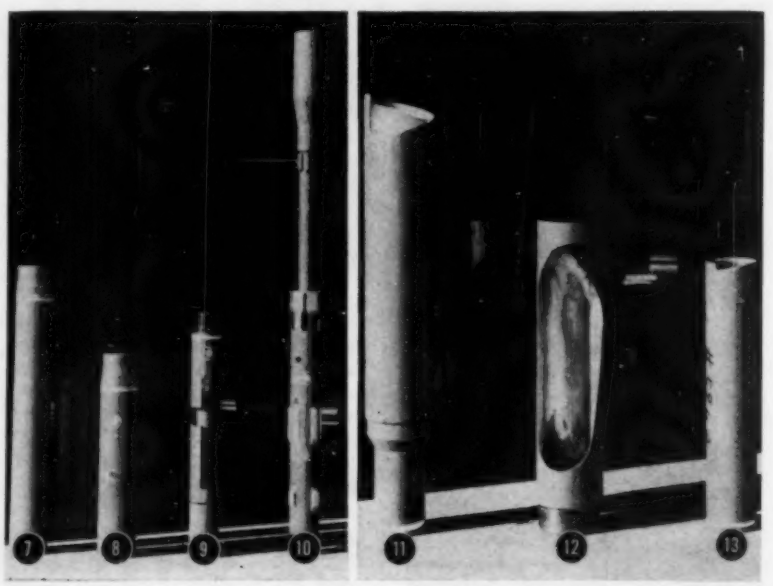
Numerous abnormal expenses were incurred. Wear and tear on equipment was unusually severe. Repeated use of jars, for example, shook the derrick so heavily that every few days rig builders were brought in to "run" the derrick and tighten or replace bolts constantly being shaken loose.

At no time did Carter consider junking and abandoning the well.

The well had been drilled through



FIFTY SPECIALIZED FISHING TOOLS were used during the 99-day battle. Here are 13 of those employed. There are: (1) Washover rotary shoe; (2) drill collar stabilizer and tight hole reamer; (3) outside cutter for cutting drill pipe; (4) inside cutter; (5) taper tap; (6) spear; (7) extension nipple; (8) control bushing; (9) J-type safety joint; (10) washover drill collar spear; (11) overshot with inside grapple wickers; (12) wall hook, and (13) top box.



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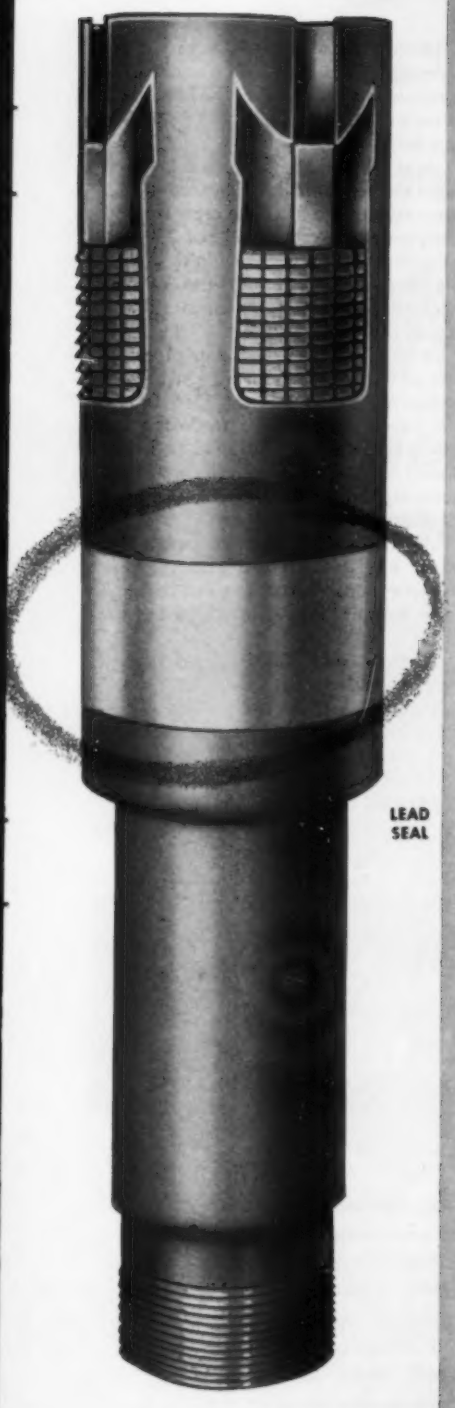

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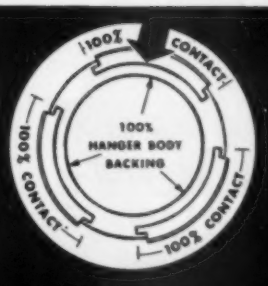

LOOK BEHIND THE SLIPS

Specialized Construction provides each slip with 100% hanger body support throughout the entire length of slip travel—no cracked or broken slips—positive operation—all the area of each slip securely grips the casing.

1. BURNS LEAD SEAL CASING HANGER *with hold down slips. Slips set automatically after casing is suspended.*
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pay formation, and only heavy mud held back the high-pressure, sour, corrosive hydrogen sulfide gas. This threat of possible blowout of the sour gas complicated every step of the fishing job.

Unless the fish was recovered and the well completed or properly plugged with cement, the gas might find its way to a porous formation higher in the well and eventually reach the surface through other wells or an outcrop.

To whipstock at this time, the company would have had to abandon 8400 ft of hole that had cost more than $10 a foot to drill. In addition, Carter would have to pay the contractor more than $40,000 for drill pipe lost in the hole. And in all probability, a new hole would have encountered fishing troubles, too.

While trying to free the fish at 11,000 ft, drill pipe again stuck at 4950 ft. Sides of the hole began caving. While trying to wash over drill pipe after bouncing past the pipe at 4590 ft, the drill pipe parted again.

This time, the break was higher up the hole at 3940 ft. Both drill pipe and washover pipe were stuck in the hole. Then the hole caved so heavily fishing experts could not find the top of the fish. At one point, a drill bit went 300 ft down alongside the fish without touching it.

During the next week, a varied assortment of specialized tools and instruments was lowered down the hole in an effort to find and take hold of the elusive fish.

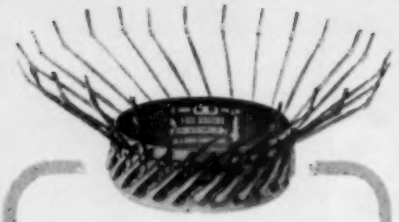
A beveled taper tap on a crooked joint of pipe finally appeared to be screwed into the fish. The crew worked the pipe and exerted a pull of 200,000 psi, but the fish wouldn't budge. Steadily losing ground, the experts backed off at a safety joint at 3268 ft inside the surface casing.

A long string of washover pipe was run to wash over the fishing string between the safety joint at 3268 ft and the taper tap at 3940 ft. When the washover pipe reached 3940 ft, it was found that the taper tap had been screwed into a hard chalk formation and not the fish.

Another week followed before the taper tap was screwed into the fish. After a month of nothing but losses, it now became possible to clean out the hole.

Early in July, a determined attempt was made to seal off the sour gas formation for protection against a possible blowout. Using a 2-in. core barrel, the fishermen cleaned out the inside of the stuck drill pipe and attempted to perforate at 12,000 ft.

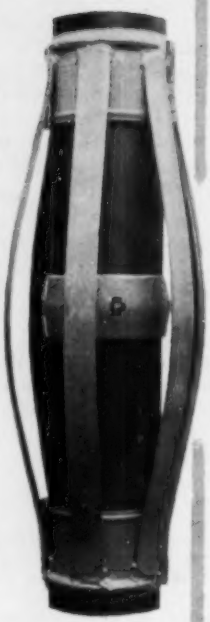
Special crews lowered perforating



for a good cement job...

B and W

SCRATCHERS and CENTRALIZERS



Removal of mud cake and prevention of channeling are required for good primary cementing.

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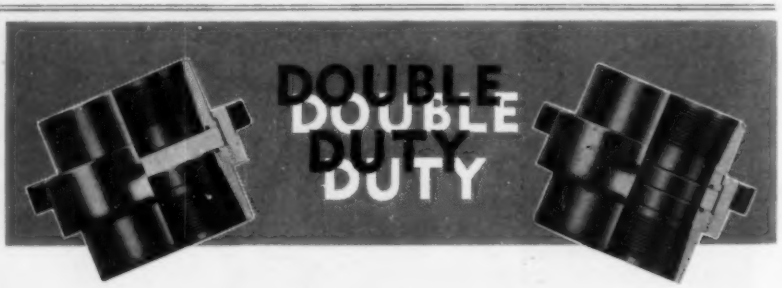

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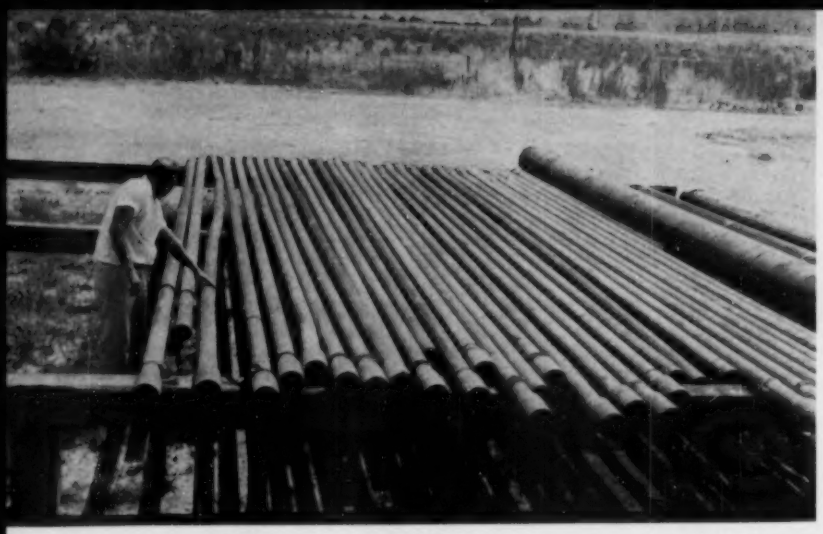


BENT AND DAMAGED PIPE during fishing job are examined by Foreman Greene. Carter paid the drilling contractor for 32 such joints.

LAST FISH RECOVERED. Fishing expert Murphy, Foreman Greene, Pumper T. H. Black and Foreman Malcolm Tudor happily admire last of two long-lost drill collars. Carter foremen worked 12-hr tours on and off during 99-day job.

guns into the hole seven times. In the heavy mud and at 240 F temperature 2⅓ miles below the surface, the first four guns failed to fire. The fifth, sixth and seventh fired, but only a few shots from the seventh penetrated the pipe. An attempt to cement through the perforations failed. Fishing then continued without protection of the sour gas being cemented off.

Again, the work of cutting the fish out of the hole, piece by piece, began. The work see-sawed back and forth until August 2. The drilling report for that day tells of the recovery of the last piece of wash pipe stuck in the hole since mid-June.

"Going in open-ended to screw into drill pipe fish to clean out, made cut at 5024 ft, attempted to cut at 5019 ft, failed to cut. Came out of hole, redressed cutter, went in and made cut at 5019 ft. Came out, put on spear, went in hole, took hold of fish, pulled loose, pulled out; recovered 5 ft wash pipe. Went back in with spear, took hold of fish jarred loose, recovered 5 ft of wash pipe. Went back in with spear, took hold of fish, jarred loose, recovered 5 ft wash pipe including shoe."

On August 16, top of the fish was at 6584 ft, and fishing was good. Decision was made by district and division officials to set 8⅝-in. casing down to 5300 ft to control the caving hole. Although casing would restrict washover work, it would reduce chances of encountering new trouble.

After casing was set, trouble diminished considerably. The crews began retrieving 400-ft lengths of the fish.

On September 15, a full 99 days and nights after the third fishing job began, pipe was backed off at 12,349 ft. The crews, on their most important of hundreds of trips in and out of the hole, stacked more than 2⅓ miles of drill pipe in the rig to reach that final joint of two drill collars.

One drill collar and one bit was left in the hole on purpose. These were below the producing formation and could cause no more trouble. Also, the 9-in. bit on bottom couldn't be pulled back through the 8⅝-in. casing set earlier to hold back the caving Midway shale.

Altogether, Cage-Sutherland 1 X cost about $450,000, or $170,000 more than the cost estimated before the well was started. Total cost of the fishing job was less than the cost of duplicating the 12,378-ft hole and paying for the drill pipe recovered.

On preliminary test in mid-October, the well flowed 146 bbl of condensate and 4,000,000 cu ft of gas per day. The produced gas won't burn without auxiliary heat because of its high carbon dioxide content.

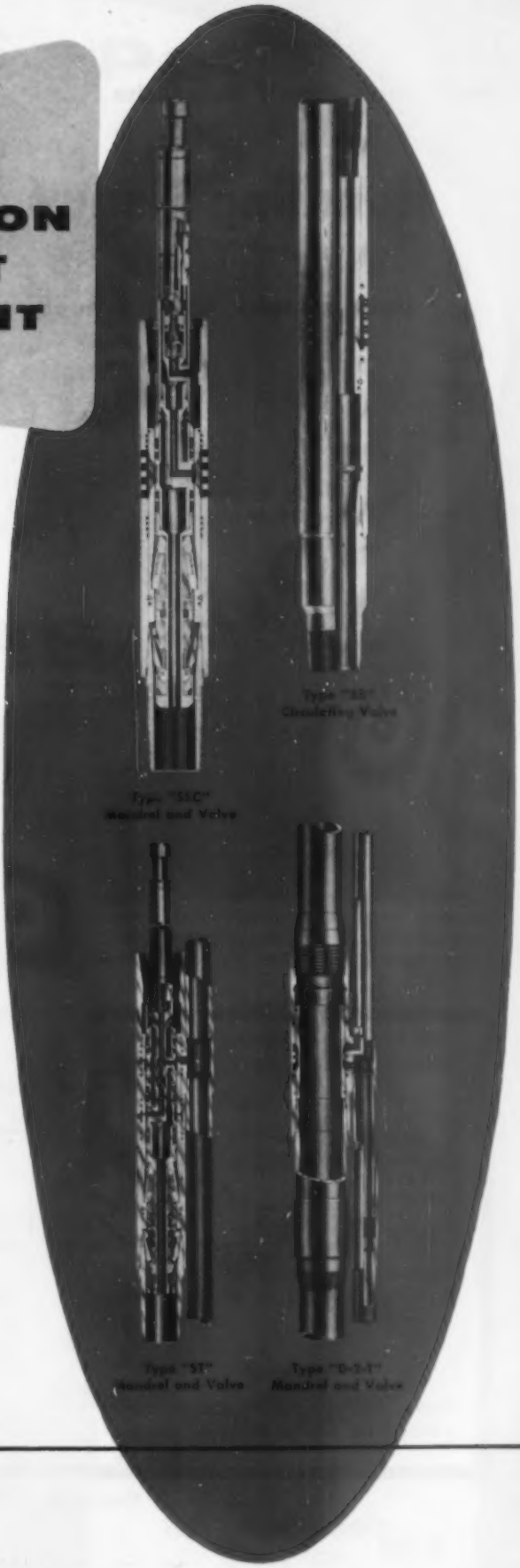
In spite of the risks and experience in drilling the No. 1 X Cage-Sutherland, Carter has a third well planned in the same area early in 1956.

Acknowledgment

Based on an article by the same name published in the November-December, 1955, issue of The Carter Oil Company's "The Link." ★ ★ ★

got

DUAL COMPLETION GAS LIFT EQUIPMENT



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Check this list against your dual completion requirements! It shows how GOT equipment can reduce your completion and operating costs.

Type "SSC" 1½" Mandrel permits running two strings of tubing equipped with wire line retrievable gas lift valves inside 5½" O.D. casing **without clamping!**

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Type "D-2-T" Mandrel permits an externally mounted gas lift valve producing through macaroni tubing to be isolated from both casing and tubing with wire line tools!

Type "B" Circulating Valves, furnished in 1½" and 2" sizes with outside diameters matching those of the "SSC" mandrels, provides surface controlled, full opening, full capacity communication between casing and tubing.

All equipment employs the time-proved GOT sliding sleeve valve. All equipment is full opening and permits use of regular tubing tools and instruments. All equipment is made of stainless steel or high strength, heat-treated alloys. All gas lift valves are mounted concentric with the tubing bore. Different types of valves interchange in every mandrel.

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EXCLUSIVE

Production Man's Headache . . .

Handling Heavy, Sand-Laden Crude

Unusual tank battery hookup solves difficult storage problem

Jerry Stumm
Pacific Coast Editor

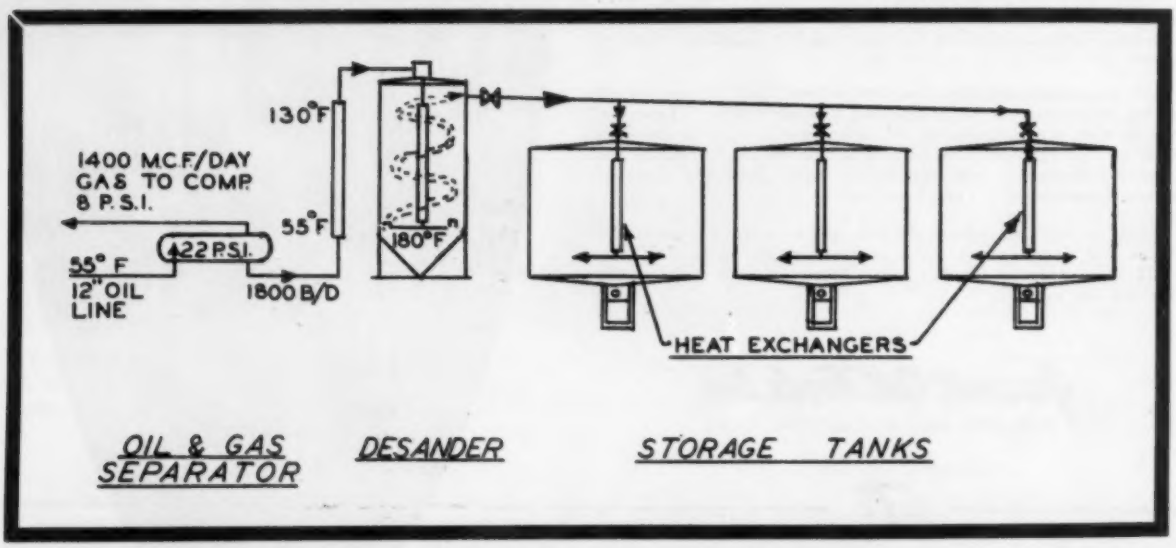
UNION Oil Company's Guadalupe field, near Santa Maria, California, may have the undesirable distinction of producing the most sand with its heavy oil. This sand problem has prompted the design and development of some rather unconventional oil storage facilities.

Guadalupe wells produce from the Sisquoc sand at a depth of approximately 2700 ft. Producing interval consists of an oil shale overlaying the oil sand. The oil shale is highly saturated, very tight and consolidated, while the oil sand is very porous, permeable and unconsolidated. Net oil sand for the field is approximately 35 ft. By core analysis, the air permeability is approximately 2 darcys and the interstitial water content varies from 20 to 25 per cent.

Drilling Program

The drilling program calls for running 8⅝-in. casing to the top of the oil shale and cementing to the surface. After drilling out the shoe, the normal clay base mud is displaced with an oil emulsion mud and a 7⅞-in. hole is drilled to the top of the Knoxville formation, which is called bottom. A 7-in. liner, approximately 120 ft long, of 29 lb, grade N-80 pipe, with 180-1½-6-16 perforations is run in and hung with a conventional liner hanger. At this point, the drill-in mud is changed over to a 20-deg crude.

Initial production from a newly drilled well is approximately 80 bbl per day of 11-deg crude, cutting 60 per cent sand with no water. This high sand cut will generally continue for several days and then rapidly decrease to 20 to 30 per cent. After several months, the cut will decrease to 6 per cent sand, and within a year it may drop to 1 per cent sand. There are exceptions, however, as some wells will cut 15 to 20 per cent sand for 6 to 12 months. Production from the new wells is switched into the oil gathering system when the



Flow diagram of heavy oil storage facilities.

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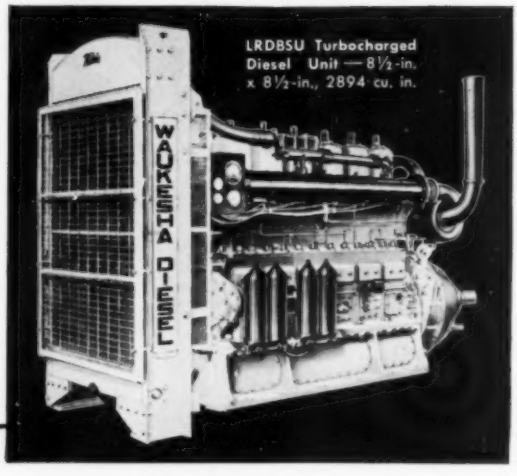

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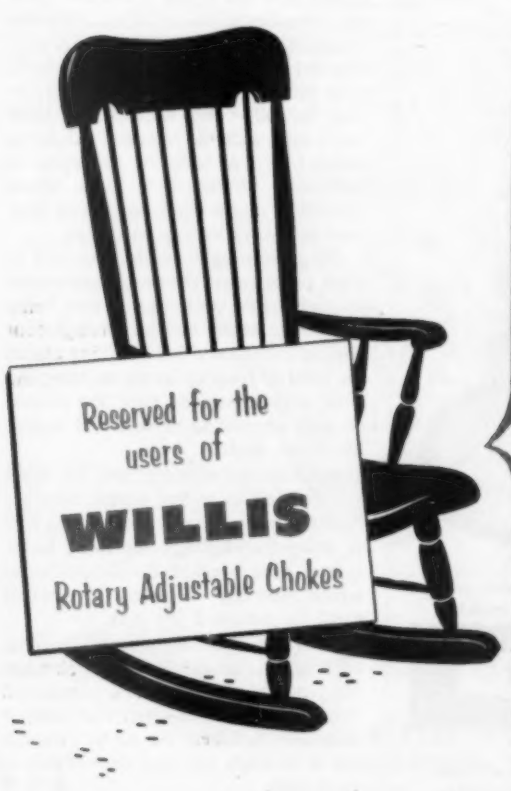
cut drops to 25 to 30 per cent sand. Because of the very viscous nature of the oil, no trouble has been encountered with flow lines sanding up. For a flowline temperature of 55 F, not uncommon in the Guadalupe field, viscosity of the crude runs about 200,000 Saybolt Universal seconds.

Gathering System

Gathering heavy oil is always a problem, and Guadalupe crude is certainly no exception. The gathering system consists of running a 12-in. main line, fed by 6 and 8-in. laterals, to the central tank setting. Individual well flow lines are 4 and 6-in. lines that terminate at weigh meter settings on the laterals and main gathering lines. The wells are individually metered through a manifolding system. For future development of heavier crude producing wells (9 to 10 deg), the same type of gathering system is contemplated, but with the aid of a diluent.

The main gathering line transfers crude oil and casing gas to the tank setting for separation, cleaning, and storage. Oil and gas are combined and flow into a horizontal separator. Oil is then directed through a heat exchanger and into a second gas trap. Gas is gathered and delivered to a compressor plant for sales.

UNION OIL COMPANY'S EXTRACTOR PLANT in Guadalupe field collects 11-deg crude from a 12-in. main line. Individual well flow lines range from 4 to 6-in. in diameter. After gas has been eliminated from the oil in the horizontal separator, crude is directed through a heat exchanger and delivered into the specially designed 34-ft high desander.



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From the second trap, the oil passes through another heat exchanger that is the down spout in the cone bottom desander. Oil is discharged at the bottom of a desander into three inverted flumes. The buoyant force of water in the desander floats the oil to the water-oil interface. Sand drops out of the oil into the water and settles to the bottom. Clean oil maintains a pad with the excess flowing to the storage tanks and is further heated if necessary.

Gas and Sand Separation

Heat for the separation process is supplied by one, low-pressure, 15-psi, locomotive-type boiler through a thermal siphon system. This heats the field production from 55 F in the desander by two stages as outlined above. Each heat exchanger consists of 130 1-in. by 20 ft tubes in a 30-in. diameter jacket. It has been determined that when the oil is heated to 145 F in the first heat exchanger, the crude gravity will drop 5 deg. The desander also has a critical temperature range. Temperatures below 170 F allow globules of oil to settle out with the sand and thereby be discharged to the sump. Temperatures of 180 F reduce this sort of waste oil.

Gas-oil separation is accomplished in a standard 5 by 20 ft horizontal separator that employs impringement, centrifugal motion, and gravity as the separating forces. Low viscosity and high solution gas-oil ratio were the factors for selecting the large horizontal-type separator having more surface area and also providing longer detention time. Due to the high sand content in the oil, no oil valve was used. Instead, a float actuates the gas valve, which maintains the oil level.

The cone-bottom desander carries a 13-ft water level, operating very similarly to a wash tank. The desander is 16 by 34 ft high, the height consisting of a 10-ft cone, 13-ft water level, 3-ft oil pad and an 8-ft area for froth and pressure head to fill the stock tanks. The 130 F oil enters the second gas trap at the top of the desander for final separation and then is directed through a down spout heat exchanger that raises the oil temperature to 180 F. From this heater, the oil enters three 6 by 12-in. inverted flumes and is directed spirally up the desander about 13 ft to the oil pad. As the oil passes from the heater to the flumes, 90 to 95 per cent of the sand drops out; a portion of the remaining sand settles out of the oil into the water as the oil spirals upward. Sand is dumped from the cone six times daily. Frequent desanding washes the cone and prevents the sand from sticking on the walls and thereby sanding up the desander.

Stock Tank Facilities

The accompanying photograph illustrates how the crude gravitates from the desander to one of three 3000-bbl insulated tanks. These tanks are constructed differently in that they have cone bottoms and heat exchangers to heat the oil. Cone bottoms are tank roofs used as tank bottoms, the slope being 1-in. per foot. At the apex of each tank bottom is a 12-in. wheel valve that dumps into reinforced concrete spillways leading to sumps.

Oil gravitating from the desander to stock tanks enters the center and passes through a heat exchanger before being discharged at the bottom through four 4-in. spreader bars. Center filling causes the sand to cone up in the middle, and with a cone-bottom tank the largest amount of sand to be removed is near the 12-in. drain.

With the aid of water jets, the tanks are cleaned in a few hours, whereas with flat-bottom tanks a day and a half is generally required. Cleaning is required once every 2 or 3 months, at which time approximately 300 bbl of sand are removed per tank.

To further facilitate tank cleaning, each tank is manifolded to a circulating pump so that oil can be transferred from one tank to another. The pump is also used to reheat the oil by circulating it through the heat exchangers in each tank. * * *

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FINANCING THE DRILLING OPERATION

W. K. Powell*

THE elements of financing the drilling operation are basically the same for all users of drilling equipment. Despite some misconceptions, the conduct of business in boring oil wells is largely the same for the drilling contractor and the oil operator utilizing self-owned rigs. There are no financial costs or requirements more applicable to one class of rig owners than others. There would be little variation in the techniques or procedures in financing the drilling operation if it were not for the natural influence of the multi-differences in the complete capital structure of each of the various owners.

Functionally, there appear to be three distinctive forms of financing involved in the drilling business. As with other things that are arbitrarily grouped, these three tend to blend, to some extent, in practice. In the order in which they will be encountered these forms are:

1. **Capital investment or long term financing**
2. **Working capital or immediate financing**
3. **Supplemental working capital or intermediate financing**

Other groupings are not excluded but it is believed that these will be helpful in examining the fundamentals involved and therefore sufficient for this basic discussion.

Capital Investment or Long Term Financing

Since the purchase of drilling equipment ordinarily precedes the other fiscal problems it provides a logical starting point. The money must be obtained to buy working tools and plans made for the recovery of that money before the tools are exhausted. It may be assumed that the equipment is being acquired for employment in the making of a monetary profit or for other advantages that will eventually culminate in an expected real gain.

The simplest way to buy drilling equipment is to use capital already owned. Write a check against deposits. Or convert stocks, bonds, royalties, oil payments or other liquid assets into money and thence into drilling equipment. Or the money may be dispensed with by resorting to barter. Additional assets may be drawn into the business through contributed surplus or stock sales and this increase used in paying all or part of the cost of purchased equipment.

The ease with which the capital of a company can be expanded depends upon the nature and background of the particular organization. An oil producing company may sell additional issues of stock quite readily whereas a company engaged solely in the hazardous business of drilling by contract may find few or no takers for its offerings. Regardless of how the organization comes by its invested capital, this purchase financing method is that of the substitution of one form of owned asset for another.

Even the largest and strongest companies do not always find it convenient to pay out of pocket or increase their capital to acquire drilling equipment. Instead, they borrow in one manner or another. The poorly endowed do the same for the simple reason that they don't have enough money to buy without borrowing. So the procedure is an honorable and practical one that is only hazardous when used injudiciously. The sources for loans are limited and specialized. There is a general prejudice against advancing money for rig purchases due to a number of causes. Chief among these has been the poor experience resulting from indiscriminate loans to improperly managed enterprises.

*President, Beard Drilling Company, Duncan, Oklahoma.

Loan Sources

Some loans for the purchasing of drilling equipment are secured from private sources. Individuals advance money, in the form of loans, to organizations in which they are keenly interested. Occasionally, individuals lend for such inducements as high interest rates, bonus and exceptionally fine security. Probably the most common occurrence of private financing results from private sales of drilling equipment in which notes are given as evidence of indebtedness resulting from the transaction.

Banks, in general, find the drilling business frightening and are not inclined to lend money with drilling equipment as the only security. A few of these institutions, having broader experience, do make loans to very select applicants but, as with other types of loans, they do not expect to carry more than 40 per cent to 50 per cent of the appraised value. Most of the bank loans on drilling equipment are made as an adjunct to oil production loans or when additionally secured or guaranteed by responsible endorsers.

By far the largest part of rig financing is done by suppliers and manufacturers. These people are equipped with the facilities and experience to sell drilling equipment on credit terms. The range of possible arrangements is great as the terms of any specific transaction are determined by the combined effects of a number of varying factors. Reputation, worth, experience and abilities are measured to define credit limits. The ability to keep any rigs purchased employed profitably during a high percentage of the time in each year influences the credit seller as this insures the means by which the loan account can be retired promptly. Being specialists in their work enables the suppliers and manufacturers to judge these factors competently.

It is usual for such vendors to require the buyer to pay from 10 per cent to 50 per cent of the purchase price in cash if the buyer is acceptable otherwise. At times, some sales are made to established firms without any down payment. In such cases the seller may be motivated by special regard for the purchaser's abilities or may hold some additional collateral.

Bonded Indebtedness

In the case of larger organizations, the issuance of bonds may be the source of borrowed capital. This method for obtaining capital to purchase tools has been barely explored by drilling companies although it offers very interesting possibilities. Specialized types of bonds, similar to those sold by railroad companies to finance rolling stock, may be developed to obtain funds. Protection for the bondholders could be provided in the same manner as is done with railroad equipment bonds.

Regardless of the source of financial aid there are certain obligations to repay that are required. It is usual for the borrower to contract in writing to pay back the amount of the loan with some specified interest at a designated time and place. The promise to pay is in the form of a note which becomes the legal evidence of indebtedness.

The conditions under which the loan is made are recited

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in the loan contract which includes reference to the manner in which payment of the note is to be secured. Any collateral that is provided is covered by a trust assignment, with instructions, or by a mortgage and deed of trust. The note may be payable in installments that recur on a designated time interval pattern agreed upon by the lender and the borrower.

New Repayment Patterns

Such conventional practice of stipulating installments on regularly recurring time intervals does not recognize the realities of the drilling business. Fixed interval payments were designated for those commercial enterprises which produce a steady influx of income and enjoy a uniform depreciation rate on the collateral involved. Neither is characteristic of the drilling operation. There are periods of intense drilling activity interspersed haphazardly with dormant periods that result in a pattern of highly fluctuating income and exhaustion, through wear and tear, of the drilling equipment pledged as security.

To overcome these difficulties there has been a trend towards formalizing the recognition of such unpredictable factors. This has been accomplished by tieing the commitment to make payments to the use of the equipment instead of to an arbitrary time pattern. Payments against loan obligations are computed at an agreed rate per working day multiplied against the total days of useage.

This retires the loan in direct ratio to the depletion of the collateral. When the drilling equipment is being used up and worn out the payments keep stride with such wear. During idle times the borrower is not under pressure to secure money with which to make payments on fixed commitments. In the case of a drilling contractor this protects against the compulsion to accept contracts below cost in order to meet a fixed payment schedule. And to the operator employing financed rigs for his own use a more flexible drilling program is made available.

To meet legal requirements, this type of loan normally stipulates a minimum payment that must be made within given fiscal periods and a fixed date for the final satisfaction of the loan. The minimums are generally quite modest in amount so as not to destroy the purpose of the use-commitment contract. The final due date is calculated by allowing sufficient total time on the loan to permit the borrower's average drilling activity to become effective.

It must be noted, that for all practical purposes, supply companies and manufacturers often handle their loans in this manner. The strict letter of the loan agreement is waived when work for drilling equipment is at a low ebb. The suppliers do not want to force their customers into destructive competition. And the borrowers are anxious to conserve cash on hand for operating capital. This is entirely a voluntary and optional procedure that depends upon the character and needs of both parties of the formal financial agreement.

Collateral Security

Practically all loans on drilling equipment are made in such a manner as to protect the seller or lender with collateral security. Although the equipment itself is normally accepted as collateral under a mortgage agreement there may be additional assets pledged. It is not uncommon to find drilling equipment and other assets under mortgage serving the dual purpose of securing the long term or capital loan and also providing protective forfeit, to the extent of its excess, for open account financing.

Renting of collateral is something of an innovation in the field of finance that may be rarely encountered in connection with rig loans. This device has been used most commonly to borrow money for the purchase of stocks and bonds. The borrower obtains collateral, usually in the form of negotiable stocks or bonds, from a third party by agreeing to pay rent for the same while it is being used as security. In the case of drilling equipment financing, such rented collateral would probably come from someone vitally interested in the welfare of the borrowing organization. A corporate officer might rent or lend assets to a corporation to augment its borrowing power. Or a partner might supply personal assets to a partnership for the same purpose.

Whatever terms are agreed upon for the loan, prudence requires an effective plan for the retirement of the loan. All concerned will want the payments to remain in excess of the depreciation of the collateral. Consequently, it is good practice to earmark adequate amounts of income for interest payments and loan liquidation. When such sums are not to be paid out immediately they should be conserved in reserve accounts. If their admixture in the general bank deposits tend to lose their identity the funds can be placed in a special bank account.

Any plan for designating money to be used for the loan retirement should take into consideration some leveling process to extract applicable funds from the general income during periods of active operation. Particular stress should be given to this accumulation if the loan agreement provides for rigid payment dates.

The assumption has been made that the owner of the drilling equipment regards such machinery as capital business purchases capable of enough potential productiveness to repay its own cost. The term capital purchases has been used to designate physical items of substantial life that are, or will be, used to accomplish the purpose of the organization owning such capital goods.

Working Capital or Immediate Financing

After acquisition, drilling rigs must be operated to be of value. This imposes an immediate requirement for money to pay labor, taxes, insurance, supply, repair, bit, fuel, mud, water, hauling and other operating bills. Such funds are referred to as working capital or immediate capital. There is a constant and rapid turnover of this money when the rigs are active. The original working capital fund is periodically replenished from the receipts for drilling. The excess over these requirements is alloted to debt retirement, if any; to reserve accounts for depreciation, replacement and hazard; and to profit and surplus.

How much money is needed for the working capital of any given organization is a constantly recurring problem. The amounts needed are governed by the number of rigs to be operated simultaneously and the nature of the work they will be doing. The working capital investment is regulated by the time required on prospective wells multiplied by the cash cost of each operating day times the number of rigs to be operated.

Corollary measures for time and cost can be determined from the drilling agreement:

1. **Location of work**
2. **Season in which work is to be performed**
3. **Accessibility of labor and supplies**
4. **Hazards**
5. **Adequacy of fuel, water and services**
6. **Knowledge of formations to be drilled**

Any organization will be financially more sound if it owns all of the working capital it needs. However, since this is not always possible, the working capital requirements are frequently supplemented. The sources for additional working capital are almost identical with those for capital investment.

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For more detailed information about the new "Hydraplex," write for Bulletin No. BJO-778.

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Open Account Purchases

The practice of purchasing supplies on open account provides the most common method of supplementing working capital. Materials, supplies and repairs used in operations are charged on account if the buyer's credit is good. Most of the resulting bills are not due, with discount, until the 20th of the month following the month of purchase. On shallow or quick drilling, when the time is under thirty days, the drilling may be reimbursed before supply bills are due and thus the working capital needs are drastically reduced. There is also the resulting financial advantage in the trade discounts amounting to as much as 2 per cent of the purchase price.

By special arrangement longer credit terms may be obtained from suppliers. This may be necessary when deep or difficult drilling ties up substantial portions of the working capital for long periods. After the discount date noted above has passed there is usually an additional thirty days allowed without interest but with no discount privileges. Any time longer than this is at the option of the seller and when granted carries interest on the unpaid balance at rates of from 5 per cent to 6 per cent.

In considering the supplier as a source of additional working capital it should be remembered that accepting terms beyond the discount date is very expensive. The loss of 2 per cent on a month's purchases may be considered as a cost of 2 per cent per month or 24 per cent per year for the use of this additional working capital. It may be possible to secure money elsewhere at a much lower rate of interest. The interest on money borrowed at 6 per cent per annum for any time less than four months will be less than the 2 per cent discount earned on bills paid with such money.

Therefore, when the net worth of an organization warrants or when sufficient security is available, it may be more economical to borrow such money as may be needed for short terms to increase the working capital temporarily. Private investors and banks will make such loans. They may be considered as intermittent and continuous until the working capital has been adequately increased through accumulation.

The cost of such financing may induce an increased capitalization of the organization. The addition of working money could certainly be paid for by taking all purchase discounts in an active operation.

Care must be exercised to prevent an increase of capital beyond actual needs. Unused capital could result in a poor appearance for the organization when earnings were compared to investment.

The issue of bonds for operating purposes would not appear to be practical except in very special cases. Because of the spasmodic needs for supplementary working capital, in most cases, the cost of the long term, non-retireable bond money could not be offset regularly by earning through discounts. If the funds secured from the sale of bonds could be employed fully in operations they would earn their cost.

Such a condition might arise in connection with long term off-shore contracts. But this would be feasible only when the money could be used in expanded operations which might be expected to earn sufficient profits to eventually supply the needed working capital and retire the bonds. The real problem would be in convincing potential bond purchasers that the enterprise was sound and had an adequate plan for liquidating the bonds at due date.

Supplemental Working Capital

The relationship between intermediate and immediate capital requirements is so close that an explaination is necessary as to why this designation was made. To distinguish any funds needed in excess of ordinary working capital and investment capital the name intermediate financing was arbitrarily selected. This is money used to supplement that provided by working capital for all normal operating needs. The necessity for such supplemental cash arises as unusual conditions are encountered.

Common among these are slow paying accounts. The working capital is replinished from time to time by receipts of payments for completed work. When such reimbursement is delayed for appreciable lengths of time the available working capital is reduced. Until collections have been made the amounts thus impounded have to be secured from other sources. When considerable work is being done the total sum temporarily frozen may become quite significant. And the cost of handling such work increases by the resulting expense of the additional financing with either owned capital or borrowed money.

There are other factors which may give rise to the need for supplemental working capital. An unusual occurrence, such as a lengthy fishing job or the delay in arrival of casing for completion, may impose an additional financial burden. Time is so vitally connected to the measure of required working capital that any disturbance tending to increase working time materially will usually result in a demand for intermediate financing.

Borrowing Against Receivables

Much of this financing is done by drilling contractors through borrowing against accounts receivable. Organizations conducting their own drilling operations will likewise borrow short term money to meet such intermediate requirements. Most banks will lend money to be paid out of the receipts from completed and invoiced work. The loan will not exceed the invoice amount as the banker relies on the formal or informal promise to repay out of the proceeds from the billing.

In most instances, when there is an actual assignment of the invoice for security purposes, the notification of the company being billed is withheld to protect the borrower's sales relations. Filings in the various counties involved provide sufficient notice to the public. Formal notice to the principal addressed by the invoice is made only in the case of an impending default.

Borrowing against accounts receivable is also done for the purpose of supplying ordinary working capital needs. Only an analysis of particular transactions could distinguish this use from the foregoing. However, it is very helpful to be able to recognize the difference in order to plan for the financial needs of the organization.

Conclusion

A concise understanding of the ways and means for financing the drilling operation is a prerequisite to good management. To know the functions of the various types of capital employed is to have a key to the solution of the financial problems that are ever present in the drilling business.

One will not go blithely about the everyday business saying: "Now, we must go to the bank this morning and borrow $60,000 to supplement our working capital and $30,000 more for intermediate capital." Rather, these observations will be a part of the deeper, penetrating meditation that projects the whole business clearly into its true relationships. These are part of the plans for tomorrow's financial campaign.

Herein were discussed the things that are being done — the conventional procedures — in financing the drilling operation. Each was at one time an original solution to a financial problem. But all of the answers have not been found. The person of imagination and ingenuity will improve the old ways. The successful person will endow the industry with new solutions to its financial problems.

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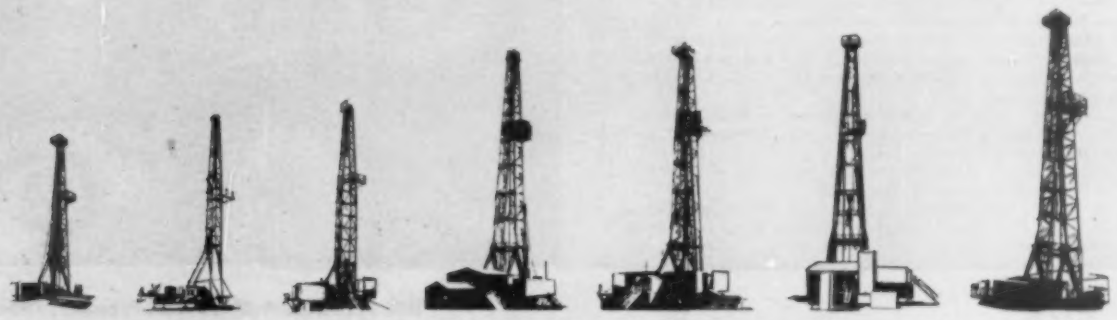

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THE OASIS — *A gathering spot for NOMADS*

NEW YORK'S 1956 OFFICERS have been elected. They are, seated, Sergeant-at-Arms Don E. Kircher, Gardner-Denver; Treasurer Dave C. Washburn, Cameron Iron Works; President Herb E. Maland, R. J. Eiche & Associates; Secretary E. E. Andreason, W-K-M Manufacturing, and Regent Stewart D. Beckley, Beckley, Haltom & Hickman. Standing are Assistant Sergeant-at-Arms R. E. James, Security Engineering; Assistant Secretary F. L. Crabbe, Black Export, and Assistant Sergeant-at-Arms Jesse Hickman, Beckley, Haltom & Hickman. New Officers not shown are Vice President Maurice F. Delano, R. S. Stokvis & Sons; Assistant Treasurer D. T. O'Connor, D. T. O'Connor, and Regent N. L. Boulden, Jr., International General Electric.

Dallas-Fort Worth Chapter Has Rally, Schedules Ball

Good and loyal Nomads of the Dallas-Fort Worth group were hosts to principals of the American Association of Oilwell Drilling Contractors at a special "Rally Meeting" on January 23. The rally, held at the Hotel Adolphus, Dallas, heard an address by Eugene McElvaney, an officer of the First National Bank in Dallas.

The chapter has slated its annual formal dinner dance on February 11 in the Embassy Ballroom of Dallas' new Statler Hilton Hotel.

Tulsa's Fifth Inaugural Ball Highlights Social Season

Tulsa Chapter's 1956 Nomad Ball, held at Stauffers Ballroom January 26, drew some 200 couples. It is considered one of the most popular functions in Tulsa each year.

Dinner, which preceded the ball, had a menu consisting of Cornish game hen. Music for the dance was by Paul Neighbor's orchestra and was held in Tulsa's largest ballroom. Decorating the hall consisted of transforming the inside into a giant tent through the use of colored muslin, in keeping with the Nomad theme.

OUTGOING PRESIDENT of the New York Chapter, Stewart D. Beckley, at right, is being presented an inscribed silver tray by Secretary E. E. Andreason. Presentation was made at a business meeting at the Hotel Biltmore on January 9.

NOMADS Meeting Dates and Secretaries

New York Chapter, first Monday of the month, Biltmore Hotel, New York. Executive Secretary E. W. Hoeppner, in care of Hughes Tool Co., Room 4414, 30 Rockefeller Plaza, New York 20, N. Y.

Houston Chapter, second Monday. Ye Olde College Inn, Houston, Texas. Executive Secretary, Harry E. Estes, P. O. Box 14343, Houston 21, Texas.

Los Angeles Chapter, second Wednesday, Jonathan Club, Los Angeles, California. Executive Secretary, W. A. Sawdon, P. O. Box 848, Hollywood 28, Calif.

Tulsa Chapter, third Friday, Mayo Hotel. Executive Secretary, E. L. Thomas, P. O. Box 4033, Tulsa, Okla.

Dallas-Fort Worth Chapter, first or second Monday. Secretary, H. A. Davis, H. A. Davis Power Equipment Company, 2142 Irving Boulevard, Dallas, Texas.

Don Collins Heads Tulsa's New Officers

Tulsa Chapter has elected as its 1956 president Don Collins, vice-president and district manager of Republic Supply Company.

Other new officers include Junior Regent Jack H. Beesley, Baroid; Senior Regent Gilbert Swift, Well Surveys, Inc.; Vice President Cecil C. Crider, Bethlehem Supply; Secretary Oscar Irizarry, Petroleo Interamericano; Treasurer Guy F. Williams, Dowell; Assistant Secretary John Pearce, Superior Iron Works & Supply; Assistant Treasurer Paul V. McGivern, McKissick; Sergeant-at-Arms E. J. Handley, Midwestern Instruments, and Deputy Sergeant-at-Arms W. O. Timberlake, Lucey Products.

Gilbert Swift is the outgoing president.

CHRISTMAS PARTY — Seen at the December meeting of the Los Angeles chapter of the Nomads are Bill Powell, Emsco Manufacturing; Elmer Weis, Pacific Pumps; Nancy Cameron, hostess; John Neale, Lane Wells; Art Weis, Pacific Pumps.

INTERNATIONAL GUESTS and speaker of the evening at the December 14, 1955 meeting of the Los Angeles Chapter. Standing are W. M. Thompson of D. & E. from Arabia; Robert L. Walker of Shell en route to The Hague; Jim Welty of Cal-Tex Sumatra from Borneo; John Reeves of Baker Transworld en route to Maracaibo; Mercer Martin of I.P.C. from Iraq; Lawrence R. Garten of I.P.C. from Iraq. Seated are I. P. Uitentuis of Shell from Borneo; Reza Almaee of General Petroleum from Iran; Pedro de Garay of J. E. Douglas from Mexico; William T. Powell, President of Emsco Mfg. Company, speaker of the evening; Joe Turner of Aramco from Saudi Arabia; Sid Broom of I.P.C. from Arabia.

LOS ANGELES OFFICERS new and old, are Leo Cypher of Baash-Ross, Treasurer 1955; Jas. D. Hughes of Lane-Wells, Regent 1955; H. J. Schlarb of Emsco, President 1955 and Regent 1956; Harry E. Hester of McCullough Tool, President 1956 and Vice President 1955; Tom G. Martin of R. J. Eiche & Associates, Vice President 1956; standing, J. Murray Walker of Lane-Wells, Deputy Sergeant-at-Arms 1956; Wallace A. Sawdon, Executive Secretary; John S. Page of Page Oil Tools, Assistant Treasurer 1956; H. Rex Collins, Jr. of Hydril, Treasurer 1956 and Deputy Sergeant-at-Arms 1955; John McEwen of Stansbury, Inc., Assistant Treasurer 1956; Earl R. Atkins, Consultant, Secretary 1955; Harry M. Taylor, of Bettis Rubber, Assistant Treasurer 1955; Knight Templeton of S. R. Bowen, Assistant Secretary 1955; Robert P. Gaylord of Wagner-Morehouse, Secretary 1956 and Sergeant-at-Arms 1955.

U. S. reserves predicted with confidence to be in range of 40 billion bbl rather than popular 29-plus billion bbl figure

Oil Resources of The United States

Paul D. Torrey
Orchem Corporation
Austin, Texas

SINCE it was organized in 1947, the Secondary Recovery and Pressure Maintenance Committee of the Interstate Oil Compact Commission has been engaged in an inventory of fluid injection operations and in an appraisal of the additional oil that may be obtained by the application of fluid injection techniques in the fields of the United States. These studies have been made by states and in cooperation with state committees appointed by the respective governors. The members of the state committees and of the compact committee are recognized as the leading authorities in this highly specialized field.

In order to encourage activity on the part of state committees and to make available useful information without great delay, the compact has published separately numerous reports on secondary recovery and pressure maintenance operations in several states. The reports have been accepted widely by regulatory authorities and by industry as the most complete and most reliable source of information available on these operations. Because of the magnitude of the work and because of the continued growth of the compact, it has not been possible previously to assemble statistical information with sufficient rapidity to enable its publication on a national basis. However, for several years the compact committee has regarded a national survey to be one of its principal objectives. At the 1954 winter meeting in Chicago, Illinois, it was apparent that studies in the various states were sufficiently advanced to insure the accomplishment of this objective in 1955. Thus, the committee is now able to give the compact estimations of the oil that existed originally in the fields of the United States, the maximum additional oil that is believed to be recoverable by the application of fluid injection methods, and the additional oil that is beleived to be recoverable by these methods under the economic conditions that existed at the beginning of 1954. It will be recognized that the presentation of this information represents an important achievement by the committee.

In Table 1, United States Oil Resources as of January 1, 1954, various statistics are listed by states. In order to show the great significance of fluid injection operations in the United States, reserves that will be recoverable by primary methods have been differentiated from additional reserves that will be recovered by fluid injection.

In general, it will be noted in Table 1 that primary reserves estimated by the compact committees (Column 5) are slightly smaller than API proved reserves (Column 4), which is to be expected since the API reserves include some oil that will be recovered as a result of secondary recovery and pressure maintenance operations. However, if the committee's primary reserves are added to the reserves obtainable by application of fluid injection methods under the economic conditions that prevailed during the early part of 1954 (Column 7), the sum is considerably greater than the API proved reserves. The fact that the findings of the two committees are not in agreement is not surprising, and really is no cause for concern. The compact committee takes the optimistic view that the results that have been obtained in literally hundreds of fluid injection operations, in almost every oil-producing state of the nation (and for which there is now a historical record in some fields of 35 years of continuous operation) are sufficiently dependable to be used as a criterion for the estimation of the possible additional recovery that can be obtained from the oil fields of the United States.

It will be understood, of course, that there are oil fields in the United States that will not require any form of fluid injection to insure maximum economic recovery. Also, it will be recognized that economic conditions are going to control the feasibility of fluid injection operations in many fields. It is believed that the extensive background of knowledge and experience possessed by the members of the compact committee and the state committees qualifies these people better than anyone else to judge just how much additional oil can be obtained.

*Chairman, Secondary Recovery and Pressure Maintenance Committee, Interstate Oil Compact Commission.

Editor's Note: *Application of presently known methods of oil recovery would boost this country's recoverable reserves from the popular API figure of 29 billion bbl to 40 billion bbl, an increase of some 39 per cent. By utilizing the best known production methods on all oil fields in the U. S. as of January 1, 1954, the ultimate production would amount to 88 billion bbl (past production plus recoverable reserves) and 184 billion bbl would remain in the ground, an overall recovery of only 32.4 per cent. These facts, presented at the Interstate Oil Compact Commission meeting last year in Denver, Colorado, pointed up the importance of increased recovery. This paper, "Oil Resources of the United States," and its companion paper, "Magnitude of Fluid Injection Operations in the U. S." by Albert E. Sweeney Jr., are presented together here through the courtesy of the IOCC, and also because the editors feel this subject merits the attention of those engaged in oil recovery work.*

In a contemporaneous paper, "Some Early Contributions to Petroleum Technology from Fluid Injection Operations," the writer has discussed how the coring of oil reservoir rocks and the analysis of cores have been used to evaluate the recovery that can be obtained from fluid injection operations. In addition, core analyses make possible the calculation of the existing oil content of reservoirs. If this figure is added to the past production of any field, the original oil content of its reservoir can be determined. Thus, the various committees, commanding as their members do, vast sources of reservoir information, have been able in most cases to report their estimations of the oil that existed originally in the fields of their respective states (Column 1). From these figures, the original oil resources of the presently known fields of the United States are obtained. Although 271,933 million barrels of oil is a very impressive figure, Dr. George H. Fancher, one of the best informed authorities on the subject as a result of his extensive studies of the oil fields of Arkansas and Texas, advised the writer, after a cursory review of incomplete statistics, that the total figure for the United States was certainly on the conservative side and, very conceivably, could be much larger. In any event, there can be no disagreement with the conclusion that the United States has been bountifully and abundantly supplied with crude oil, for the original oil resorces of the nation are almost ten times the present proved reserves as estimated by the API committee.

Total past production (Column 2) is taken largely from API figures although in a few cases production has been reported that varies slightly from them. The total difference, however, amounts to only 20 million barrels, which is a small fraction of the combined past production of all of the states.

1953 oil production (Column 3) is taken exactly from API figures as is also the case for proved reserves (Column 4).

It will be evident that many of the state committees and geological surveys believe that their respective primary reserves are higher than API estimations. This is a matter of opinion, and certainly need not be cause for contention for it is well known that the OPI Reserves Committee periodically has revised and increased its estimations of proved reserves as new fields have been discovered, as the area of known fields has been expanded, or as deeper reservoirs have been found in older fields.

The maximum recovery of 29,137 million barrels (Column 6) that can be

Tips on Mud Valves for Toolpushers . .

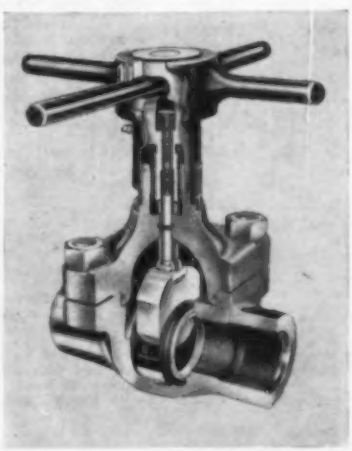
John Norman and Hank Bierman, Edward salesman, discussing MUDWONDER construction which simplifies maintenance and makes operation easy.

MUDWONDER Cuts Operating Cost On 9 Rigs By Stopping Expensive Mud Valve Repairs

by John K. Norman, Assistant Vice-President
Schafer Drilling Company, Oklahoma City, Oklahoma

BUYING mud valves is one place we found during the past three years you can cut costs without cutting dependability or service life. On our nine rigs we replace all worn valves with Rockwell-Built MUDWONDER.

MUDWONDER cut-away view shows the double thread construction, separated stainless stem and hard chromed gate with "T" slot connection and the one-piece seat insert with the buna-N molded integrally over the steel wear rings.



Although the MUDWONDER is competitively priced, mud valve maintenance and repair costs have been practically eliminated under this new policy. Just recently, for example, we replaced our first parts on a two year old MUDWONDER on a mud gun.

Inspections or part replacements when necessary are quick and easy. When the bonnet has been removed, the gate slips off the stem and the one-piece seat insert lifts out of the body. Our crews can replace either of these parts while a connection is being made.

Easy operation added to simplicity of maintenance makes the MUDWONDER our best mud valve buy. We are now using them on standpipes and mud guns very satisfactorily.

I can recommend MUDWONDER to any toolpusher having mud valve trouble. MUDWONDER valves are built in 2", 3", and 4" sizes with screwed or flanged ends for 2000 psi WP (4000 psi test) and 3000 Psi WP (6000 psi test).

Your favorite oil field supply store can give you complete information, or write Edward Valves, Inc., East Chicago, Indiana. Shipments can be made from East Chicago or the Edward Houston warehouse through the supply store you select.

obtained as a result of the application of fluid injection figures exceeds slightly the proved reserves estimated by the API committee. As indicated previously, the recovery of all of this oil is problematical, and will be dependent, among other things, on economic conditions in future years. It is important to know, however, that this considerable quantity of oil is susceptible to recovery by known methods.

The recovery of over 11 billion barrels of oil that can be obtained from application of fluid injection methods under the economic conditions that existed at the beginning of 1954 (Column 7) is a much more definite figure. It is the belief of the compact committee and the state committees that this amount of oil can be recovered in addition to the primary reserve. Therefore, the present oil reserve of the United States is predicted with considerable confidence to be in the range of 40 billion barrels rather than around 29 billion barrels. This amounts to a very significant increase of some 39 per cent.

If the combined primary and fluid injection reserves are added to the past production of the oil fields of the United States, it will be seen that the known fields of the nation will probably produce eventually some 88 billion barrels of oil, which amounts to a recovery of 32.4 per cent of the original oil in place. The 184 billion barrels that will remain is, indeed, a challenging problem from the standpoint of the tremendous energy potential involved, for the security of the nation, and because the production of oil contributes so much to the maintenance of governments and to the comfort and welfare of the people. The fact should be emphasized that the efficiency of oil recovery processes has been improved greatly in the last few decades, and there is no reason to believe that improvement will not continue in the future. Therefore, it can be foreseen that greater recovery of the nation's oil resources will be obtained in the future than has been the case in the past.

There is unanimity among the best informed authorities that much higher oil discovery rates or much greater utilization of existing reserves are going to be necessary to increase United States producing ability sufficiently to satisfy the nation's anticipated expansion in consumption of petroleum products, which is expected to amount to 3 billion barrels per year by 1960. The number of wildcat wells that have been drilled in the United States to provide crude oil for what has been a constantly increasing demand has more than doubled from pre-World War II years to the present. Nevertheless, the percentage of oil wells completed during this period has declined sharply and the percentage of dry holes has increased sharply. For that reason the cost of discovery and development of new oil fields has increased tremendously. Thus, as new oil reserves are becoming more difficult and more expensive to find, the nation will have to place more and more reliance in the future on oil than has already been found, on imports, and on other sources of energy.

Maximum utilization of oil that can be obtained only by some form of fluid injection, will, undoubtedly, be a gradual process although the importance of these methods is increasing steadily in many states. A realistic appraisal of the effect of improved recovery technology might be that sufficient additional oil will be produced by this means during the next 20 years to in large measure supplement the anticipated increased demand. The widespread application of fluid injection techniques, therefore, will contribute greatly to the nation's self-sufficiency in oil supply.

As mentioned before, the information presented in this paper has been

TABLE 1.

Oil resources of the U. S. as of January 1, 1954.

All figures in millions of barrels

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Source of information
New York	743	190	3	49	0	75	64	New York Secondary Recovery Committee.
Pennsylvania	3,831	1,180	11	111	0	805	111	Pennsylvania Topographic and Geologic Survey.
West Virginia	2,560	449	3	37	53	598	52	West Virginia Secondary Recovery Committee.
Kentucky	1,500	287	11	82	90	300	50[1]	Items (1) and (2), Kentucky Geological Survey.
Ohio	4,232	631	4	32	25	150	7[1]	Jack Cashell, chairman, Ohio Secondary Recovery Committee.
Indiana	1,575	237[2]	12	62	50	275	75	Indiana Department of Conservation.
Illinois	7,000	1,688	58	625	400	2,000	1,000	Illinois Secondary Recovery Committee and Illinois Geological Survey Division.
Michigan	1,340	362[2]	12	61	80	258	88	Michigan Geologic Survey Division.
Kansas	12,900	2,470[2]	115	913	850	350	150	Secondary Recovery Division, Interstate Oil Compact Commission.
Oklahoma	43,800	6,815[2]	200	1,752	1,500	1,500	700	Secondary Recovery Division, Interstate Oil Compact Commission.
Louisiana	17,124	3,293[2]	238	2,760	2,558	3,767	1,695	Louisiana Secondary Recovery and Pressure Maintenance Committee
Mississippi	2,925	394[2]	34	350	355	1,000	72	Mississippi State and Oil Gas Board.
Arkansas	3,155	879	28	358	208	1,399	1,255	Arkansas Oil and Gas Commission.
Texas	94,400	16,780[2]	1,002	14,999	15,662	11,540	5,000	Texas Petroleum Research Committee and revised from report of Texas Petroleum Research Committee.
New Mexico	6,125	864[2]	70	815	731	165	84	New Mexico Oil Conservation Commission and Secondary Recovery Committee, Interstate Oil Compact Commission.
Colorado	3,000	238[2]	36	319	328	300	200	Clark F. Barb, chairman, Colorado Secondary Recovery and Pressure Maintenance Committee.
Wyoming	9,063	1,138[2]	83	1,279	1,209	906	270	
Montana	1,624	198[2]	12	208	195	142	13[1]	
California	54,000	9,699[2]	365	3,919	3,305	3,500	614[1]	Items (1) and (5) revised by G. B. Shea, Bureau of Mines from data developed by C. L. Moore PAW District No. 5.
Other States[3]	1,036	45[2]	15	214	187	107	27	
TOTAL	271,933	47,817	2,312	28,945	27,786	29,137	11,527	

Identification of Columns

(1) Estimation of Original Oil Content of Reservoirs.
(2) Total Oil Production to January 1, 1954.
(3) 1953 Oil Production.
(4) Proved Reserves from API "Proved Reserves of Crude Oil, Natural Gas Liquids, and Natural Gas on December 31, 1953, Volume No. 8."
(5) Primary Reserves as of January 1, 1954.
(6) Estimation of Maximum Recovery Obtainable by Application of Fluid Injection Methods.
(7) Estimation of Recovery from Fluid Injection Under Economic Conditions as of 1/1/54.

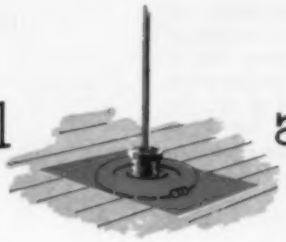
Footnotes

[1]From National Stripper Well Survey, January 1, 1954.
[2]From API "Petroleum Facts and Figures," Eleventh Edition, p. 115.
[3]Includes Alabama, Nebraska, North Dakota, Utah, Florida, Missouri, South Dakota, and Virginia.

Everything?..

Yes. Everything!

...to drill



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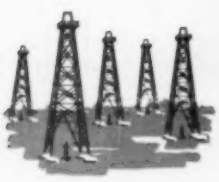

oil fields of the world

derived from a variety of sources, among which should be identified: State regulatory authorities, state geological surveys, the Bureau of Mines, and the various state committees that cooperate with the Interstate Oil Compact Commission. Information developed by the National Stripper Well Survey and contributed by Albert E. Sweeney Jr., director of the compact's Secondary Recovery Division, has been used freely and to great advantage. Also, the data presented would not have been nearly so complete if it had not been possible to utilize statistics compiled by the API Committee on Petroleum Reserves under the leadership of Dr. F. H. Lahee. The writer and other members of the compact committee have had occasion several times to confer with Dr. Lahee and members of the reserves committee. Invariably, we have been received graciously and have obtained constructive consideration of the problems at hand. For all of this help and support, the writer is profoundly grateful, and it can be stated with certainty that this paper could not have been prepared without the assistance that has been received.

P 537.5

Magnitude of Fluid Injection Operations in the U.S.

Albert E. Sweeney, Jr.
Interstate Oil Compact Commission
Oklahoma City, Oklahoma

By 1960, annual production from flooding alone will about equal the total oil production by water injection today, judging by experience in past five years

FLUID injection operations during 1953 produced approximately 425,000,000 bbl of oil. This is larger than any single state's production with the sole exception of Texas. Production from these fluid injection projects produced more oil than the combined total of Alabama, Arkansas, Colorado, North and South Dakota, Florida, Illinois, Indiana, Kansas, Kentucky, Michigan, Mississippi, Missouri, Montana, Nebraska, New Nexico, New York, Ohio, Pennsylvania, Tennessee, Utah, Virginia, and West Virginia.

Approximately one-half of this total was produced by unitized projects, according to a recent survey[1]. This survey indicated that the 258 fully unitized projects produced 208,000,000 bbl in 1954, and that a total of 3,500 million bbl of increased recovery is expected from these operations.

In Fig. 1, Recent Growth of Secondary Recovery in the United States, the growth is divided between gas injection and water injection projects. The decrease in number of projects in 1946 is, in part, explained by the consolidation and combining of leases into single projects; whereas in 1941 each

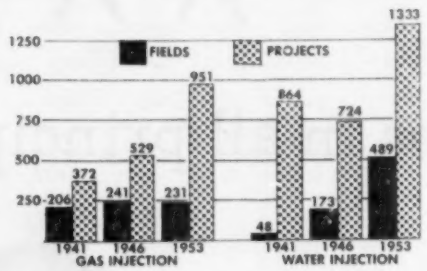

FIG. 1. **Recent Growth** of secondary recovery in the U.S. divided between gas injection at left and water injection at right.

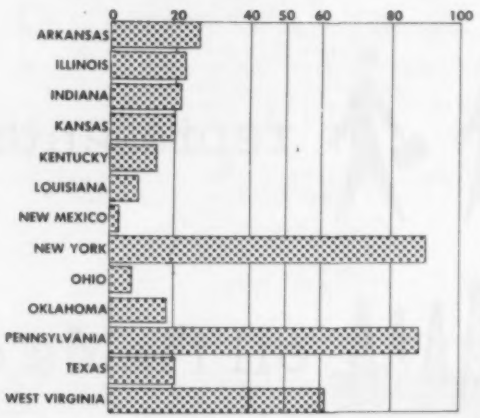

FIG. 2. **Production from Fluid** injection in per cent of total production is shown for several states for the year 1953.

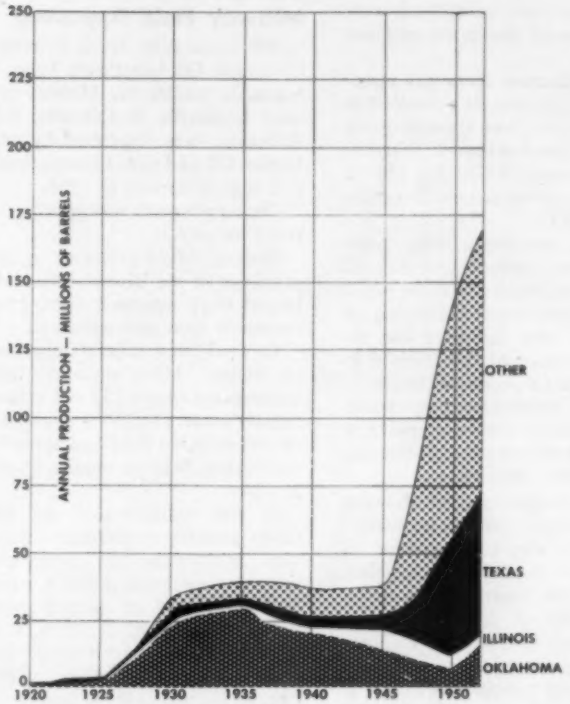

FIG. 3. **Annual Production** from gas injection projects in the U.S.

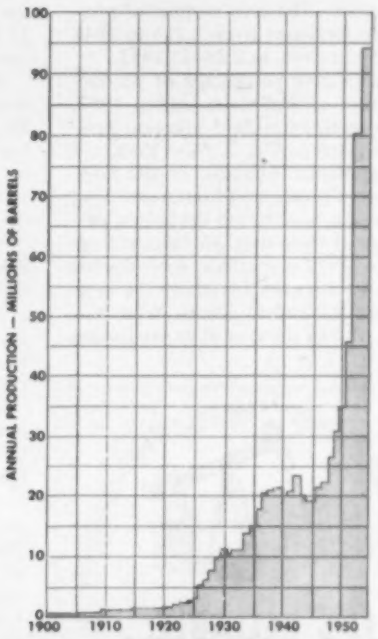

FIG. 4. **Growth of Production** from water flooding has climbed rapidly since 1946.

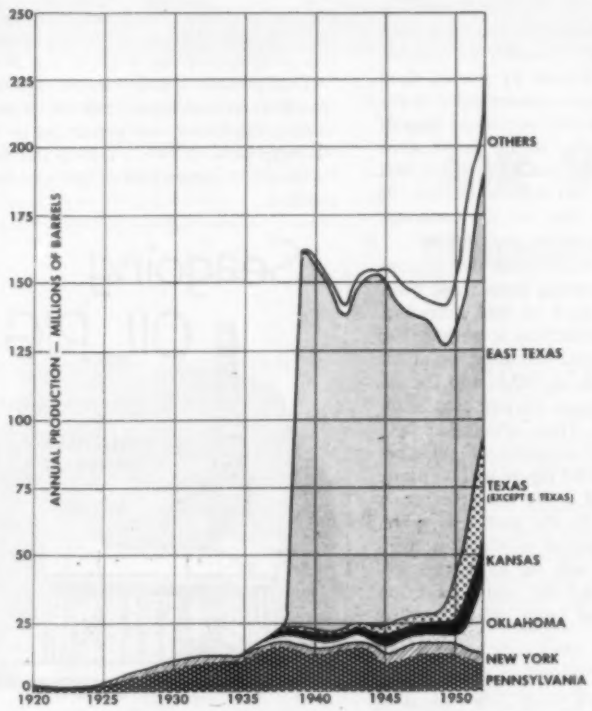

FIG. 5. **Annual Production** from water injection projects in the U.S. with East Texas shown in relation to other states.

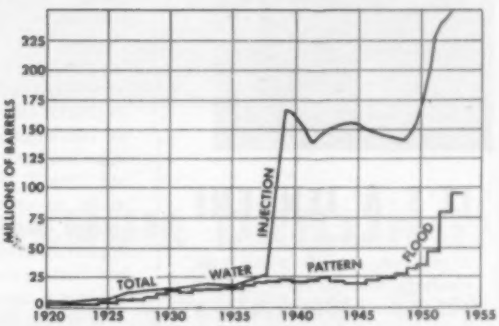

FIG. 6. **Relative Proportion** of production from water injection projects in comparison with production from water flood projects in the U.S.

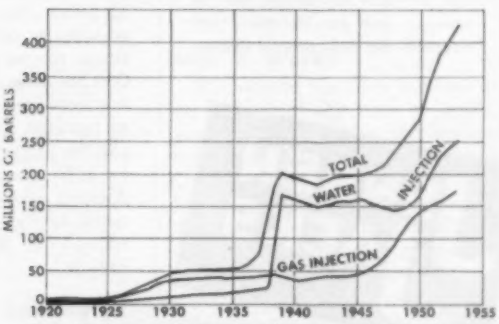

FIG. 7. **Annual Production** from fluid injection. Comparisons between production from water injection, gas injection and total indicate the rapid growth of production from both methods of fluid injection.

lease, in most instances, was carried as a project. The total number of projects has increased from 1,236 in 1941 to 1,253 in 1946, to 2,284 in 1953.

The relative percentage of production from several states during 1953, which came from fluid injection projects is given in Fig. 2. New York and Pennsylvania, because of the large amount of production from water flood operations, have by far the largest percentage of their state production from these types of operations. Several other states are considerably above the average for the United States. West Virginia, with 61 per cent of its production from fluid injection operations, Arkansas with 25 per cent, and Illinois with 21 per cent are all above the national average.

Annual production from gas injection projects is graphically presented in Fig. 3. Production from these projects has increased from less than 10,000,000 in 1925 to about 37,000,000 bbl in 1935, and to approximately 200,000,000 bbl in 1953.

The annual production from water floods is shown graphically in Fig. 4. This illustration demonstrates the rapid growth of this method of increasing oil recovery, and also indicates the increasing importance of this method in a number of the oil producing states.

The annual production from water injection projects is shown graphically in Fig. 5. This includes the production from water-flood projects.

In Fig. 6, a composite graph showing the data from Fig. 4 and 5 is presented. This shows the relative proportion of the water injection production which is coming from the water-flood projects.

A comparison of production from water injection operations, together with the total production from all fluid injection projects is presented in Fig. 7.

Torrey[2] has presented data that indicate that 195 billion barrels of oil now known and located will be unrecovered by primary methods. This will be reduced to 184 billion barrels by presently economical methods of fluid injection, and may possibly be reduced to 166 billion barrels by use of fluid injection now not economically feasible. Don T. Andrus[3] at Grand Rapids made an estimate, which many considered excessive, that this figure was approximately 100 billion barrels. It has been shown that, on the contrary, his was a conservative estimate.

It is difficult to evaluate the amount of production coming from these projects that is a part of this increase. Water-flood production is perhaps 90 per cent additional recovery, or about 85 billion barrels in 1953, and the remaining is perhaps 10 per cent additional recovery. Thus, about 117,000,000 bbl annually of additional oil is being recovered. This figure will continue to increase, and if the next five years can be judged by the past five years, by 1960, the annual production from flooding alone will be approximately equal to the total for water injection today — at least twice what it is at present.

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1. Horner, William L., "Survey of Unitized Oil Field Conservation Projects," *Oil and Gas Journal*, April 11, 1955.
2. Torrey, Paul D., "Oil Resources of the United States," Interstate Oil Compact Commission Meeting June 18, 1955.
3. Andrus, Don T., "Secondary Recovery Research, An Adventure in Conservation," Interstate Oil Compact Quarterly Bulletin, Vol. 5, No. 2, pp. 16-26 (1946). ★ ★ ★

Unitization Project for Midway Field Approved

An application from Sunray Mid-Continent Oil Company, Tulsa, Oklahoma, to unitize the Midway oil field near Lewisville in Lafayette County, Arkansas, was approved by the Arkansas Oil and Gas Commission in its first regular session in 1956.

The application was approved effective February 1.

Sunray Mid-Continent, a pioneer producer in the Midway field and the largest single operator there, presented testimony from two witnesses.

C. D. Crites, special representative of Sunray Mid-Continent, told the commission that 87.52 per cent of the royalty owners and 99.1 per cent of the operators in the field had agreed to the unitization. Statutes require 75 per cent to agree.

It was testified that the Midway field's primary recoverable oil in 1942 was 28,000,000 bbl. With pressure maintenance it was testified, more than 34,000,000 bbl of oil had been produced by January 1, 1956. Ultimate recovery will be 65,000,000 bbl, the commission was told. By unitization operations the ultimate recovery from the field will be increased by an additional 5,000,000 bbl of oil.

The field is operated now on a lease-by-lease basis. Because of the water pressure maintenance system used, there is a possibility of future inequities in returns from wells in the field.

The pressure maintenance system, where water is pumped into the oil pool as oil is taken out, was pioneered in the Midway field in 1942. This is the first field to successfully utilize this method.

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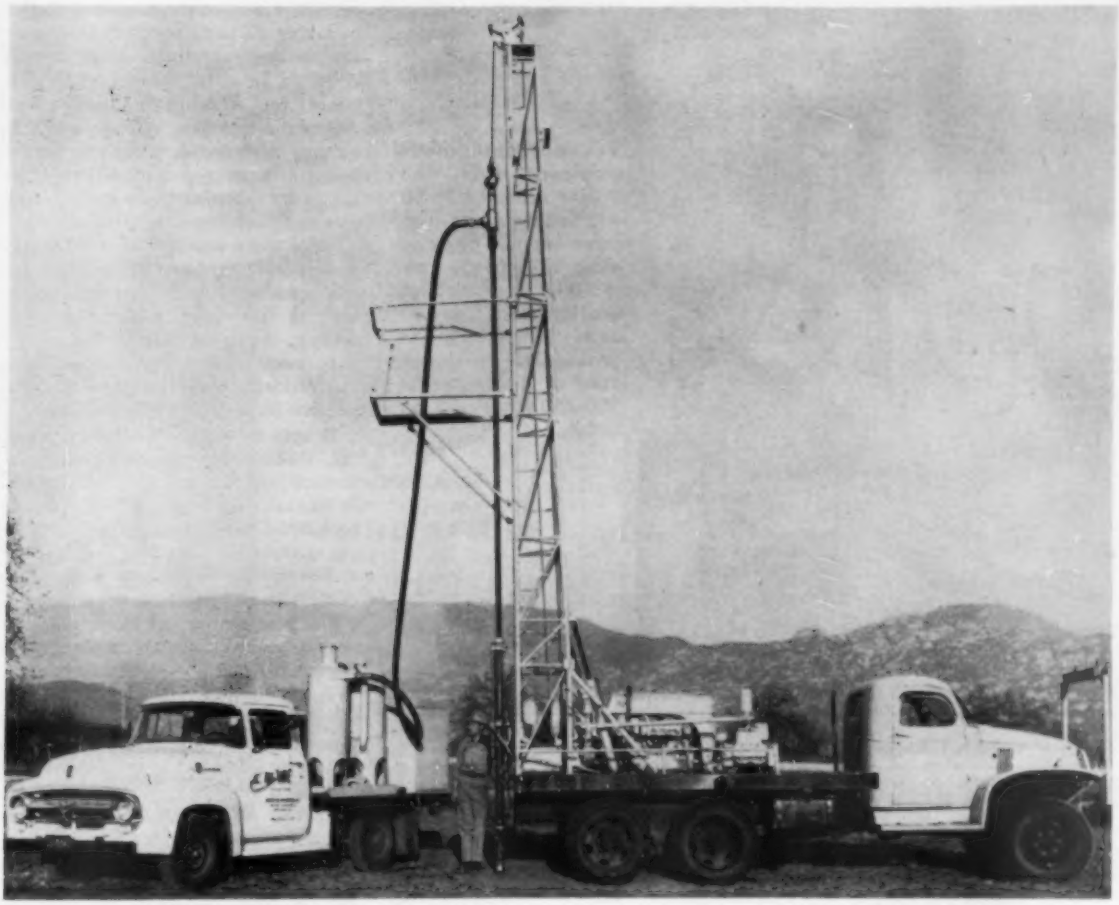


Hi-vacuum drilling system, employed on demonstration unit mounted on ¾-ton truck adapted to portable geophysical shot-hole drilling unit. Vacuum equipment may be mounted on bed of drilling unit.

AIR VACUUM DRILLING

Eliminates Lost Circulation, Dust

By reversing circulation and drawing a vacuum inside the drill pipe, new system for geophysical work solves problems of conventional air drilling.

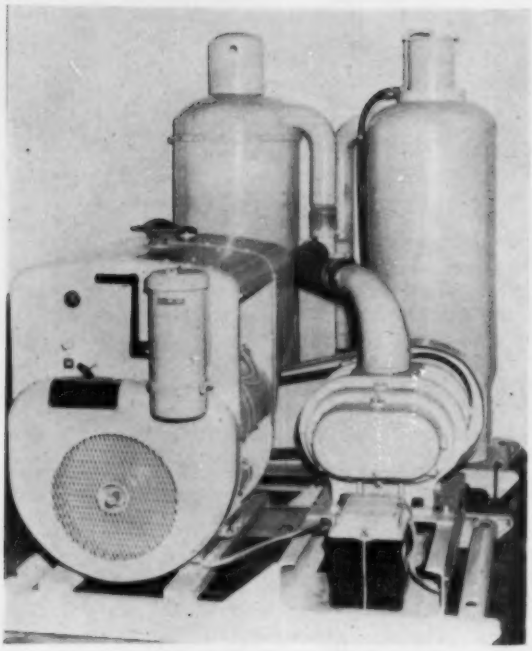
A new system for geophysical drilling, which might be described as air drilling in reverse, has been demonstrated, and proved to eliminate the majority of troubles associated with forced-air drilling.

Perhaps the outstanding feature of the system is that it eliminates the emition of dust, so prevalent in conventional air drilling, and provides a completely clean operation with no danger of drilling crews contracting silicosis. The system also eliminates the possibility of lost circulation in dry formations because it sucks in air down through the annulus and up through the drill stem, rather than the reverse used in conventional air and gas drilling. Called "Hi-Vac" drilling, this new system was developed by American Exploration Company of Santa Susana, California.

How It Works

The system removes cuttings from the bottom of the hole by pulling a partial vacuum inside the drill pipe, causing an upward flow of high-velocity air, which will extract cuttings at the rate of 1 to 36 tons per hour, depending on inside diameter of the pipe and size of equipment employed. The returning air is circulated through a filtering system separating the cuttings and removing all dust. The high-velocity air through the drill pipe instantly cleans all material from the bottom of the hole and hole walls, leaving no salting or contamination of the walls.

The system provides a geologically



Vacuum equipment employed in Hi-Vac Drilling system. A 36-hp engine drives a positive pump capable of delivering 172 cfm free air at 10 in. vacuum. Separating and filtering units shown in background. This unit is capable of drilling from 500-750 ft with a 4½-in. bit.

perfect picture of the formation drilled by taking a 1 to 10 per cent continuous sample of the cuttings, which can be collected in a transparent glass container for immediate identification. Automatic dumping of the remaining cuttings is provided, which can be disposed of wherever desired. Dry cores are easily taken with the cutting samples available for comparison.

Since there is a reverse flow of free atmospheric air down the annulus, the bits remain 24 to 60 per cent cooler than in conventional methods of air drilling, thus extending bit life.

In most cases, the system will drill material with a high water content, but will not successfully drill in water.

It appears to be ideal for geophysical, shot-hole, blast-hole, rat-hole or surface-hole drilling. It is economical to operate, requiring only about 50 per cent of the horsepower needed for present methods of forced-air drilling.

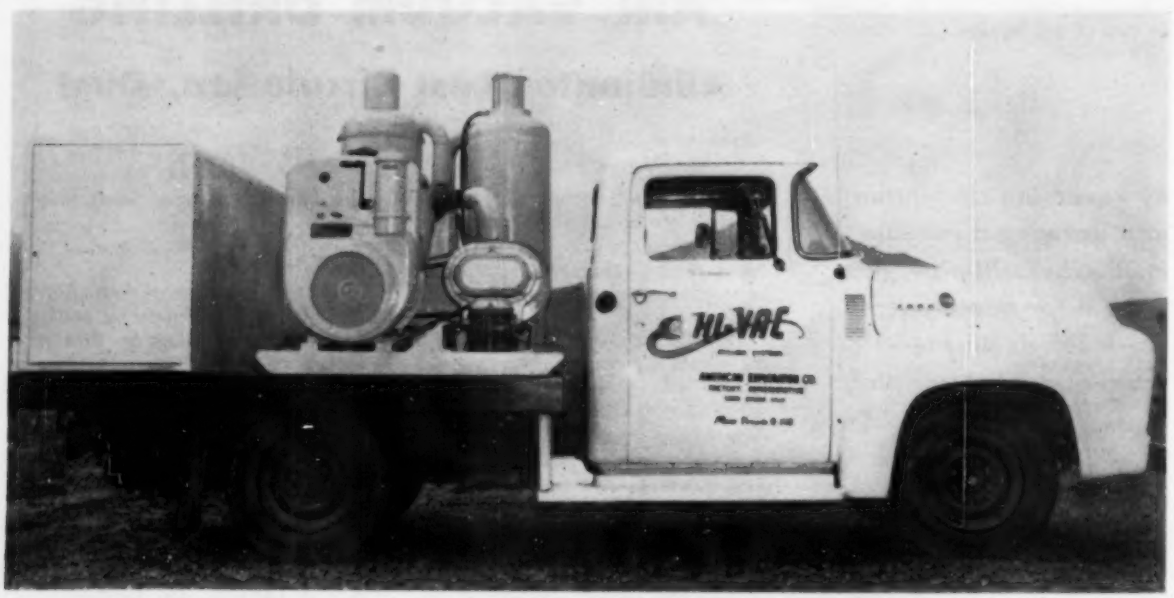
The system provides a wide range of depth and hole size, depending on the size of equipment employed, and limitations are entirely governed by frictional losses.

A 3⅝-in. hole, using 1½-in. ID internal flush drill pipe, employing a 150 cfm positive pump at 10 in. vacuum driven by a 20-hp engine, is capable of drilling from 200 to 300 ft. There are a number of sizes of units graduating up to a maximum of a 13-in. hole, using 6-in. drill pipe with a 700-cfm pump driven by a 150-hp engine, capable of drilling up to 2000 ft.

The system is easily adapted to rotary rigs and can be placed in operation in a relatively short time. ★ ★ ★

TABLE 1. Engineering data on Hi-Vac Drilling systems.

Drill pipe ID IF (inch)	Max. size bit (inch)	Pump CFM at 10 in. vac.	Motor HP	Weight	Approx. depth (feet)	Extraction of cuttings per hr in tons
1½	3⅝	150	20	1800	300	1
2	4¾	200	30	2000	500	2
2½	5⅝	300	40	2500	750	4
3	5⅝	400	60	....	1000	10
3½	8⅝	550	100	....	1500	17
4 to 6	13	700	150	....	2000	36
1	2	40	9	125	100	½



Vacuum and separating-filtering units shown mounted on ¾-ton demonstration unit. Large chest on rear of truck contains tools.

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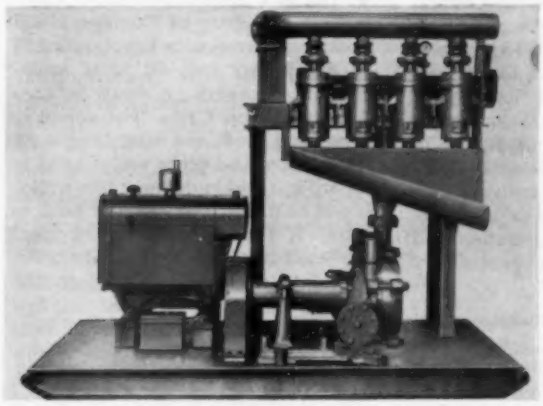

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EXPLORATION ACTIVITIES

TEXAS

★ Commercial production in the lower Permian is indicated at the Seaboard Oil-Cities Service Corrigan No. 1 test in Gaines County. In a drillstem test from 8729 to 8789 ft in the lower Permian, 1000 ft of gas, 2800 ft of 28-gravity oil and 270 feet of oil-cut mud were recovered. The test is located on a 630-acre drilling block in which Cities Service has an 87 per cent interest. Seaboard Oil Company owns the other interest. The test is approximately three miles south of Devonian production in the Alsabrook field. Operators are drilling ahead to the Devonian, expected at about 11,450 feet.

★ McDonald Oil Corporation and W. R. Goddard No. 1 Cummings, a wildcat in northwest Ector County is complete as a good discovery flowing from the upper Clear Fork. After treatment with 750 gal of acid and frac job with 15,000 gal of oil, the well flowed back load, followed by 40 bbl of new oil in one hour, through a ¼-in. choke. Oil came through casing perforations at 5640-5666 ft. Tubing pressure was 265 psi. The new field discovery is six miles northwest of Goldsmith and about 3 miles south of any similar upper Clear Fork production.

★ In East Texas, near the Louisiana state line, a new Fredericksburg lime discovery has been completed. An initial flow of 110 bbl of fluid per day has been reported at the G. E. Penn and G. W. McNeill No. 1 Pickering. The well is located 10 miles southeast of Joaquin in Shelby County. The flow included about 15 per cent water, and formation had been fractured. Flowing pressure was 100 psi, with casing perforated at 2892-98 and 2903-11 ft.

★ Confirmation of the new Dougar field in Newton County, along the upper Texas Gulf Coast, has been provided in a Beck Oil Company sand discovery. The No. 2 Kirby Lumber Corporation flowed 119 bbl per day through 7/64-in. choke at 6896-99 ft. Gas-oil ratio was 250 to 1.

★ Sun Oil Company has established a new pay zone in the Caplan field of Galveston County at its No. 9 Cade estate. The well flowed 83 bbl per day through choke from 6990-94 with gas-oil ratio of 1992 to 1.

★ New dual zone discovery has been made by Chester R. Upham and others, Mineral Wells, Texas, at the No. C-1 J. O. Castleberry. The well is five miles northwest of Boonsville, Wise County. Total daily flow from the two zones was 280 bbl. From the Atoka conglomerate, the discovery well flowed 139 bbl of 43 deg oil per day from perforations at 5020-5036 ft. Flow of 141 bbl of 42.4 deg crude from the regular pay in the Boonsville, West (Caddo Conglomerate) field was recorded from perforated zone at 4466-4483 ft. Gas-oil ratio was 450-1 on the Atoka test and 950-1 from the Caddo. Total depth of the well was 5780 ft.

★ Texas Pacific Coal and Oil Company has extended the King's Mountain pool in Upton County. The well, W. W. McClure No. 1, reached the top of the Ellenburger at 11,575 ft and the top of the Shaw at 11,665 ft. On 4 hour 40 minutes drill stem test, gas rose to surface in 35 minutes, water blanket at 1 hour and oil flowed in 1 hour and 20 minutes. Oil during the first hour amounted to 66 barrels and 70 to 75 barrels of 55 gravity oil in the third hour. Gas-oil ratio is 461:1.

OKLAHOMA

★ Deep exploration is proving successful in the prolific shallow field in the North Cement area of Caddo County. Mack Oil Company, Duncan, Oklahoma, and Drilling and Exploration Company and others have tested their No. 1 Van Zandt with a flow of 322 bbl per day, through a ½-in. choke, from the Pennsylvanian at 10,630-76 ft. Gas-oil ratio was 1201 to 1. Location is about three miles north and east of Cement. Drilexco holds three-sixteenths interest in the operation and has varying interests in approximately 1550 acres in the vicinity.

★ Union oil of California has completed its Stalnaker No. 2 wildcat in Kay County, just south of the Kansas state line. On a production test of an interval around 3600 ft the well flowed 278 bbl a day of 39.4 deg oil by heads through a ½-in. choke. The well will be placed on the pump. Union holds a substantial acreage block around the well.

★ Completion of the Gulf Coast Western Oil "A" No. 1, a wildcat gas well in Beaver County, has been announced by The Texas Company. From perforations at 6410-6414 and 6416-6432 ft, the well flowed 7,450,000 cu ft of gas per day through 2-in. tubing. Production is in the Morrow sand. The discovery well is three miles west of the Mocane field, Beaver County, the nearest production.

ENGLAND

★ British Petroleum Company's D'Arcy Exploration Company has a new field discovery in the East Midlands, at Egmanton, six miles from the Eakring, Nottinghamshire field. Four wells have been completed from the new pool, and the field is being developed as rapidly as possible. The company now has some 230 wells in the United Kingdom which produce about 1200 bbl per day. The main center of production is in the Nottingham area.

KANSAS

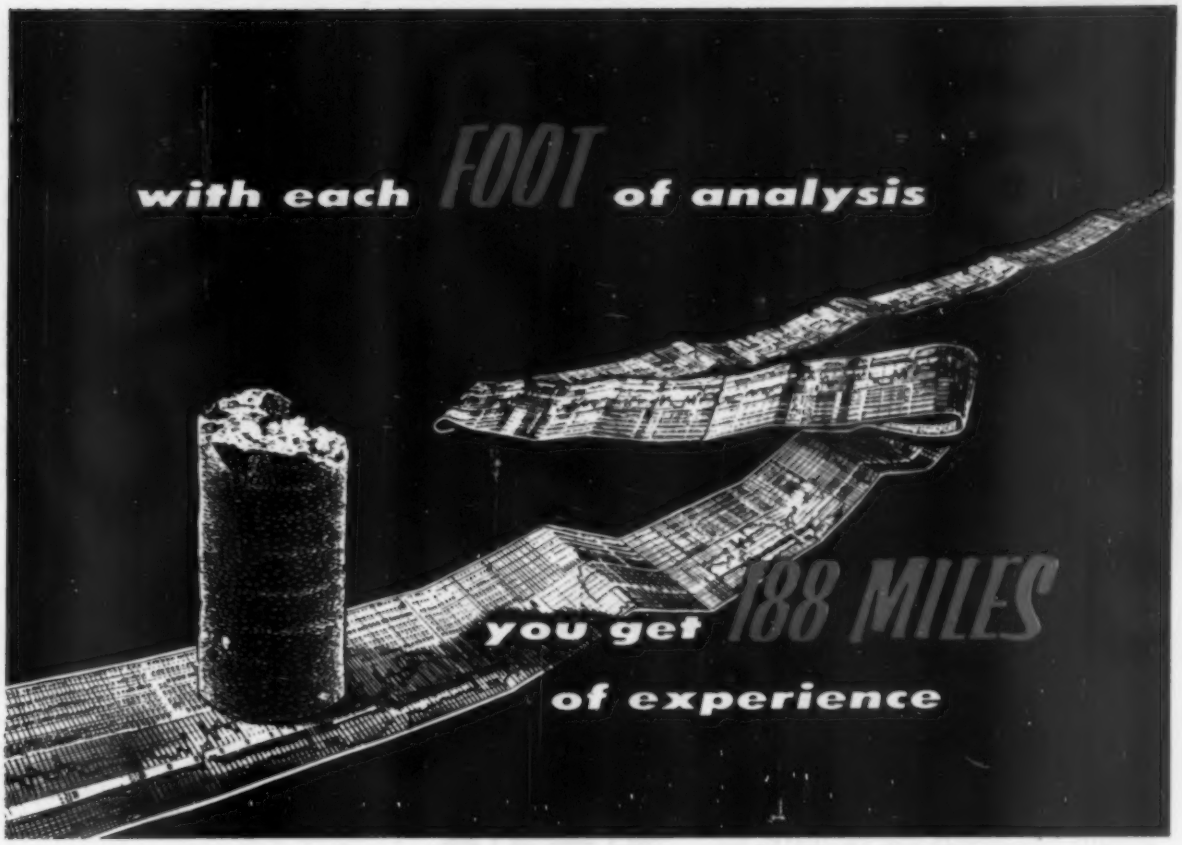
★ Lion Oil Company, a division of Monsanto Chemical Company, has completed as an oil discovery the Shinogle No. 1 in Meade County. This well is located 1,650 feet south and west of the Singley No. 1, which Lion completed as a gas discovery in mid-October. The Shinogle No. 1 flowed oil at the rate of 300 bbl per day from the Morrow sand. Lion owns a 50 per cent interest in these two wells and in 1600 acres in the immediate vicinity.

EGYPT

★ The new Sahara Petroleum Company, a subsidiary of Continental Oil Company operating in Egypt, will drill an exploratory well 60 miles southeast of Alexandria, midway between Alexandria and Cairo. The company is building roads and assembling a rig on location, and plans are to spud in the wildcat within the next few weeks. It will be drilled to a depth of 8000 to 10,000 ft. The well, which will be called the Wadi Natrun No. 1, is Sahara Petroleum's second wildcat in Egypt. The Conoco subsidiary spudded its first wildcat last summer at a site 28 miles southwest of Alexandria and is now drilling at approximately 10,200 ft, with no commercial shows recorded to date. If necessary, the first well will be carried to 15,000 ft.

WASHINGTON

★ Standard Oil Company of California has disclosed its plans to drill an exploratory well on the Olympic Peninsula in the state of Washington, two miles north of the community of Sequim. Dungeness Unit No. 1 will be Standard's eighth attempt to find oil in Washington. The company's first wildcat in the state was drilled near Moclips in 1920 and subsequent wells tested geologic structures in the vicinity of Pacific Beach, Ferndale, Alderwood, Lake Carney and Chehalis.



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Exploration

CALIFORNIA

★ Kern County Land Company is taking over as operator from Porter-Sesnon for a deepening job at Continental-Sesnon KCL No. 72-28 in the Goose Slaugh area west of Greeley in Kern County. The original operator drilled the wildcat to 10,598 ft and gave up after failing to find production in the Stevens sand. Kern County Land Company plans to carry the well on down to the Vedder sand, expected around 13,000 ft. Of particular interest is the fact that the location lies about four miles northeast of Shell Oil Company's recent Vedder discovery on the Posencula lease in the Strand field. Continental Oil Company will continue to share an interest in the venture.

★ Richfield Oil Corporation has successfully completed its wildcat, Boyle Industrial 1 in the Boyle Heights area near downtown Los Angeles. The well was completed flowing 170 bbl per day of 25.7 deg oil through a 12/64-in. choke. Production is from sands in the interval between 3130 and 3492 ft.

★ Grover Collins, operator, is drilling a wildcat on the Ross-Kirschenmann lease in the Edison area, Kern County. The well, Ross-Kirschenmann No. 64X, is located on a farmout from Oceanic Oil Company. The well is scheduled for a depth of 5800 ft for tests of the Jewett, Pyramid Hills and Vedder sands.

★ Standard Oil Company of California is preparing to drill a deep pool test near the site of the famous Lakeview gusher in the Midway-Sunset field in Kern County. The company has taken rights below 3000 ft on the same lease on which the Lakeview gusher roared out of control 45 years ago in the wildest eruption of oil ever seen. The test is expected to explore to about 7100 ft on a lease consisting of the west half of the west half of fractional Sec. 25, 12-24, about two miles north of Maricopa. The famous Lakeview gusher blew in from a depth of about 2200 ft and, during its 544 days of uncontrolled activity, produced an estimated 9,000,000 bbl of oil.

★ Geochemical Surveys and the Capital Company plan to drill a joint wildcat in the Shafter area of Kern County, one and one-half miles north of the gas discovery made by Tide Water Associated Oil Company about a year ago. Geochemical Surveys will act as operator in the venture that is expected to explore to about 4500 ft. It will be known as Shafter Gas Unit 17 No. 67-7. Tide Water has drilled several follow-up wells to their discovery on the Loepp lease, but none have proven commercial.

★ Texas Company and Union Oil Company of California have prospects of a significant Pliocene discovery in Ventura County's South Mountain field. The joint venture is the Richardson-Earl No. 1, with Texaco as operator. Completed on pump, the well is making 75 bbl per day of 33 deg crude from the Pico formation underlying the Oakridge thrust fault. The well was bottomed at 7721 ft, and marks the first production below this fault in the South Mountain field. The new production is called Bridge pool.

LOUISIANA

Union Oil Company of California has reported a major oil discovery in Iberia Parish. The well, Peterman No. 2, on Union's Hooppole Bayou Prospect, came in flowing. On a 2-hour test of the interval from 9637 to 9644 ft the well produced at the rate of 259 bbl a day of clean 41 deg crude oil through a ⅛-in. choke with 1350 psi tubing pressure and a gas-oil ratio of 438. There are additional sands to be tested and a dual completion of the well will be made. Union has 1900 acres surrounding the well.

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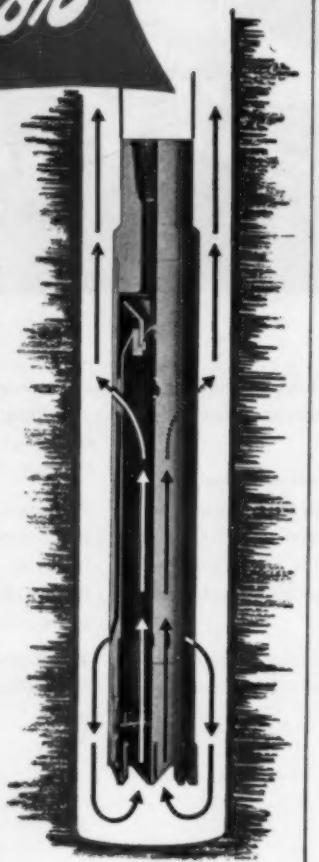

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★ Tide Water has dually completed its No. 2 Hassinger to tap two new producing horizons in the Manila Village Field of Jefferson Parish. Tide Water set two strings of 2-in. tubing inside 7-in. casing to produce its discovery. From perforations between 10,197-99 ft, the lower sand produced at the rate of 246 bbl of 24 deg oil daily through a 9/64-in. choke. Tubing pressure was 1400 psi and gas-oil ratio 655 to 1. The upper sand produced 267 bbl of 30.2 deg oil daily through a 9/64-in. choke from perforations at 9838-40 with a tubing pressure of 1500 psi and gas-oil ratio of 735 to 1.

ARIZONA

★ Hancock Oil Company of California will drill a deep wildcat in Apache County. Located on the Denne anticline in township 41n-26e, the test is slated to go to the Devonian. Nearest production is some 10 miles to the northeast in the Boundary Buttes field.

ILLINOIS

★ Location of a shallow test in Christian County has been spotted by Cities Service. The test is the Troyer No. 1, located on a 2,800-acre block, approximately 5.5 miles southwest of Pana, and 11 miles south of the North Assumption pool. Objectives are the Silurian dolomites, expected at 2700 ft.

OREGON

★ Sinclair Oil & Gas Company is drilling ahead below 11,058 ft at its wildcat in Lane County, Oregon, after setting a drilling depth record for the Pacific Northwest. The well, located 12 miles north of the town of Swisshome, is 1 Government Mapleton.

CANADA

★ Southern Production Company, Inc., has started drilling of another wildcat well in Alberta, bringing to four the number of wildcats being drilled simultaneously by the Fort Worth firm in the province. The fourth well is Southern Production-Canadian Atlantic A7-2, located in LSD 14, Section 32, Township 77, Range 6-W-5M, on a block comprising 398,400 gross acres in the Utikuma Lake area of Alberta, approximately 160 miles north of Edmonton. The well is projected to 4800 ft to test the primary objectives of the Viking, Cretaceous and Devonian formations. Two wildcats are now drilling in the Coalspur area and a third is drilling in the Valley View area of Northwestern Alberta.

★ Union Oil of California has a gas discovery in its wildcat Flat Lake 11-3, located about 60 miles due north of the Redwater field in northern Alberta. On a drill stem test of the interval between 1867 and 1918 ft the well flowed an estimated 7,000,000 to 8,000,000 cu ft of gas in 24 hours.

★ Canada-Cities Service has announced location of a Devonian test in Alberta, approximately 75 miles northwest of Edmonton. The test is its Mayerthorpe No. 1. Objective is the Devonian, expected at approximately 7650 ft. The test is approximately 35 miles west of the Barrhead pool. Canada-Cities Service has approximately 100,000 acres in the vicinity. The Canadian location has been staked in Lsd. 12, Section 14-T57 R 8w 5.

NEW MEXICO

★ Texas Pacific Coal and Oil Company has brought in an oil discovery well in the South Crossroads area. Producing from the Devonian, the State of New Mexico "O" No. 1 is located 35 miles northeast of Lovington, and 3½ miles due south of the Crossroads pool. The well flowed 83 bbl of 51.9 deg oil in 1½ hours. O ndrill stem test from 12,155 to 12,287 ft, the well was open three hours. Gas rose to surface in 50 minutes, fluid in 58 minutes, with 2250-ft water blanket recovered, and oil to surface in 1 hour. Gas-oil ratio was 641 to 1. Flowing pressure was 1750 psi and 30 minute shut-in pressure was 4725 lb.

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What's doing in DRILLING

★ **Drilling picture for 1955** is just about complete, as final figures are being tallied. On the whole, drillers racked up an enviable record. At least more holes were drilled. In Texas, where almost a third of the nation's drilling rigs are operating, 15,076 oil producers were completed. Texans also brought in 1196 gas wells and drilled 7188 dry holes. Top drilling area was West Texas, which had a rig concentration of some 420 rigs, according to Texas Mid-Continent Oil & Gas Association figures.

★ **California drillers topped 1954 record** last year by drilling 2486 wells. The 1954 count was 2330. In that state, 1956 programs got off to a slow start with only 82 new drilling notices filed with the state division of oil and gas by mid-January. In the same period in 1955, 98 permits had been issued. Accelerated drilling activity is now centered in the Wilmington field.

★ **Eleven western states' drilling total** was 4752, considerably more than the 1954 record year when slightly more than 4200 wells were drilled. Of the 1955 total number, 1896 were exploratory wells.

★ **Arkansas chalked up new records** in 1955, according to the oil and gas commission. A total of 842 wells were drilled, topping the 1954 total of 586. Last year's drilling pace was the highest since the boom days of the 1920's, the commission reports. Prior to 1953, when 583 wells were drilled, 300 projects a year had been considered a good average. Although no major discoveries were made in Arkansas last year, several fields were extended and new pay zones were found.

★ **Alabama is getting more attention** every day, although the entire state just has 115 producing wells. By the end of the year, however, Gulf Refining and Zach Brooks each added two nice wells in the Citronelle area. Gulf Refining now has five wells drilling in the discovery area, in the southwestern part of the state. Zach Brooks et al have recently completed their No. 1 Smithers, which on completion test made 528 bbl per day of 45.3 deg oil from the Rodessa zone at 10,880-964 ft. There are indications that the new field connects with a new area of production in Mississippi.

★ **New records for 1956** are already being put on the books. Deep completion of the Richardson & Bass 22,570-ft well in South Louisiana may make more headlines, but other states have some wells to be proud of, too.

★ **Kentucky has a new depth record** for drilling in that state. Shell Oil Company drilled the well, a wildcat in Chittenden County, to a depth of 8821 ft. It is the No. 1 Mildred Davis, which was drilled as a tight hole and has not yet been completed. No information has been released. Parker Drilling had the contract.

★ **A deep well in Wyoming,** southwest of Pinedale near Daniels Junction, has gone to 16,531 ft with a rig rated for 6500 to 10,000 ft drilling. The well is the Phillips Petroleum Company No. 1 Sublett and drilled by Signal Drilling Company. A 9-in. hole was drilled to 13,700 ft using 4½-in. drill pipe and fourteen 6½-in. OD drill collars. At that depth pipe size was reduced to 3½-in. OD and only 10 of the drill collars were used to 16,200 ft. Hole size was then reduced from 9 to 8¾-in. and continued downward. Main mud pump used by Signal was a 7½ by 16-in. unit with 500 input horsepower.

★ **Contractors are setting some records among themselves.** Gene Reid Drilling Company, Bakersfield, California, recently made a 240-mile move and then drilled 600 ft of new hole in about 24 hours. Reid's new mobile rig moved off location in the Santa Maria field at 6 a.m. one day and at 8 a.m. the following day was preparing to set surface pipe at a depth of 600 ft in a well near Firebaugh. Gene Reid, by the way, is a newly elected IPAA director.

★ **Three lush Mexican wells** are the pride and joy of Pemex, and have given new hope for the attainment of the 300,000 bbl daily total set for Mexico this year. Department of economy inspectors stated that the Santa Agueda No. 54 well is producing 24,000 bbl daily, the Santa Agueda No. 59, 1200 bbl per day and the Escolin, 600 bbl daily. These wells are on Mexico's eastern coast in the state of Veracruz, about 150 miles northeast of Mexico City. Pemex is planning 13 new wells in northern Veracruz in the Poza Rica, Papantla and Tihuatlan areas.

★ **Argentina has given permits for 110 new wells,** to be drilled this year by Petrobras, the government owned company. Thirty of the wells will be wildcats drilled in nine different states, including Amazonas, where six rigs will make confirmation tries near the Nova Linda, brought in last March. Another 80 wells will be drilled in the Habia oil fields, an area already under production. Petrobras plans to spend $17,000,000 on exploration and refining.

United States drilling cost trends.

Year	Total new wells completed	Average depth per well	Average contract cost per foot	Average total cost per foot
1935	24,851	2760	5.00	8.00
1936	28,962	2797	4.75	7.75
1937	35,213	2985	4.50	7.50
1938	29,127	3110	4.25	7.50
1939	28,012	3053	4.25	7.50
1940	31,149	3088	4.00	7.50
1941	32,510	3056	4.25	7.25
1942	21,990	3088	4.00	7.50
1943	20,349	3046	4.50	8.00
1944	25,786	3272	4.75	8.25
1945	26,649	3489	5.00	9.00
1946	30,230	3345	5.00	9.50
1947	33,147	3404	5.00	10.25
1948	39,477	3463	4.75	10.75
1949	38,962	3558	4.75	10.75
1950	43,204	3689	5.00	11.00
1951	44,196	3869	5.50	11.50
1952	45,879	4060	5.85	12.00
1953	49,279	4016	5.60	12.50
1954	53,650	4025	5.10	12.75
1955*	57,500	4044	4.90	13.50

*Estimated — American Association of Oilwell Drilling Contractors.

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These three properties of Unaflo provide added safety in hot, deep cementing jobs:

1. SUSTAINED FLUIDITY—Unaflo has a *retarded* set . . . stays pumpable to provide vital extra time when emergencies arise.

2. HIGH INITIAL FLUIDITY—Unaflo pumps easily right from the start—stays fluid under high temperatures and pressures.

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When you're drilling deep and your cementing slurries must go in place without a hitch—despite heat, pressure or unexpected delays—Unaflo helps protect your investment. Specify Unaflo Oil-Well Cement wherever a retarded cement is applicable.

Write today for typical data tables on Unaflo's well-bottom performance or for information on any of our other cements. Unaflo complies with API STD 10A specifications for oil-well cement, regular type classes D and E.

Standolind Oil & Gas Company's Worford Gas Unit B #1, Ignacio Field, LaPlata County, Southwest Colorado. Drilling Contractor: Reading and Bates, Tulsa, Oklahoma

CEMENTING DATA ON THIS WELL

Well drilled to 5060′ by conventional methods. High pressure gas sand at 2500′. 9⅝″ pipe set to 5047′ and plug drilled conventionally to 5060′. Natural gas at 200 to 250 psi was then used instead of drilling mud to a total depth of 7707′. 7″ pipe was then run to 7689′ and cemented with no fluid in the hole. 10 bbls. of water, 150 sacks of Unaflo and 130 bbls. of water that followed were the only liquids introduced in this well after 5060′. The 130 bbls. of water were left in the casing on top of the plug. Bottom-hole temperature was determined to be 312°F but from all indications the Unaflo cement did not dehydrate or flash-set, and another successful Unaflo job was completed under difficult conditions. The hole was then drilled out through producing formation to 8007′ using natural gas.

*"UNAFLO" is the registered trade-mark of the retarded oil-well cement manufactured by Universal Atlas Cement Company

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Resistant to Sulfate Waters

Atlas Portland Cement—Type I

Atlas Portland Cement—Type II
Resistant to Sulfate Waters

Atlas High-Early Cement—Type III

PE-U-140

UNITED STATES STEEL HOUR—Televised alternate Wednesdays—See your newspaper for time and station.

★ **Two Oklahoma companies** will drill nearly as many wells in their home state this year. APA, Inc., and Apache Oil Corporation plans to spend about $3,000,000 to drill 60 to 80 wells in 1956, Truman Anderson, APA president, has announced. The firms are very active in the Kendricks area of Lincoln County, but plan to do some drilling in southern Oklahoma, around Tulsa and in other sections.

★ **Drilling on the Humbolt Dome Structure** at Battle Mountain, Nevada, is under way by the Great Western Petroleum Corporation. Some 19 core wells drilled on the structure had preceded the big rig, and officials of Great Western and Blalack Oil Company, coowners in the venture, say that oil production is anticipated at 1900, 3500 and 4000 ft. It is expected that the first well will be carried to 5000 ft. A new group of businessmen, known as the Central Twelve, Inc., have been given a 23,000-acre lease south of Fallon for oil exploration. The Great Western-Blalack group may be planning to stay in Nevada for awhile, as drillers and crews brought their families and have set up a trailer camp all their own.

★ **Alva, Oklahoma, is bulging with drillers,** seismograph crews and their families, due to stepped-up drilling in Woods County, Oklahoma, and Barber County, Kansas. It is estimated that 120 men and their families have moved into the town just recently. Headquarters have been set up in Alva by several companies, including Gulf Oil, Petroleum Consultant, Inc., Mayes-Blevins Company, Anchor Drilling, Survey Drilling, Stanolind, and Amerada.

★ **Israel is getting American oilmen** and American dollars in quantity. In December, states one source, nearly $3,000,000 in drilling equipment arrived in Israel. Applications for new exploration licenses are pouring in. Several step out wells are being drilled near the discovery Heletz No. 1. This well is reported to be producing about 400 bbl daily.

★ **Cost cutting** is being done successfully by OK and B Drilling through the use of aluminum pipe for water lines, flow lines and connections. The company claims it saves about $300 per mile in laying the feather-weight tubular goods. Time is saved in transporting, laying, connecting, moving and breaking out. In comparison, a mile of 2-in. aluminum pipe weighs 2339 lb, against 19,800 lb for steel pipe.

★ **Cementing and gas metering courses** for tool pushers, drillers and roughnecks has been slated in several Canadian locations by the Petroleum Industry Training Service. Beginning in February a three-hour course, held on six mornings, will be taught at Drayton Valley, at Valleyview, and at Red Deer.

★ **Several newcomers to the business** are being added to the long list of contractors. In Calgary, Alberta, Canada, Moore Drilling Company, Ltd., has been formed. E. E. Moore, who will head the firm, is a former partner of Trident Drilling Company. Prior to that service, Moore was with Arrow Drilling Company in the Mid-Continent area. L & M Drilling Company has been formed by Howard B. Mitchell, Evansville, Indiana, and Dayton Loeffler, Allendale, Illinois. L & M headquarters are at Evansville. D & D Drilling Company, with offices in Denver, has been organized by Francois de Gunzberg, head of Owanah Oil & Development, and W. I. Durant, former drilling superintendent for American Liberty Oil at Casper, Wyoming.

★ **A new Graham Drilling Company** has been organized by Gene Graham for contract work in California, Oregon and Washington. The company will operate three strings of tools from headquarters in Los Angeles. Graham was executive vice president and a board director of the recently dissolved Thomas P. Pike Drilling Company. He is vice president and a director of the California Drilling Contractors Association.

★ **New offices for the Zapata companies** are under construction at Midland, Texas. Headquarters for Zapata Drilling Company, Zapata Offshore Company, Zapata Petroleum Corporation, and several other associated concerns, will be housed in a new ultramodern structure.

★ **Two drilling platforms for the Offshore Company** are nearing completion. First of the 200 by 105-ft structures is completing rigging up, following launching last month. Another is about ready for launching, construction officials report. Both platforms will be capable of drilling in 100 ft waters, and will differ in design from other similar units in that tubular caissons have been replaced with four-legged "towers."

★ **First barge for Shoreline Drilling Company of New Orleans,** of New Orleans, Louisiana, a subsidiary of J. C. Traham Company, Shreveport, has been launched in New Orleans shipyards. The Shoreline Barge No. 1, a 165 by 36 ft marshland unit, went on location for Shell Oil at Halter Island, and in less than a month had completed two wells for production.

★ **Fifth large CATC drilling tender** is under construction and will be completed in July. The $1,500,000 unit is similar to the J. C. Cleverly, J. C. Craig, Carle Sharp and Ernie Miller. The new unit will provide air-conditioned quarters for 50 men, and measures 260 by 54 ft. The floating, nonself-propelled vessel will be used in waters too deep for drilling by conventional type submersible drilling barges. Members of the CATC group are Conoco, Atlantic Refining, Tide Water Associated and Cities Service.

★ **In California, Richfield has recompleted** Coles Levee A No. 67-29 flowing 117 bbl per day of 32.8 deg oil, cutting 7 per cent through a 31/63-in. choke. Production is from intervals at 8911-8980, 9760-9950, 10,644-11,220 and 13,240-14,000 ft. The well was originally completed about two years ago in Eocene sand as the deepest producer in the world at 17,497-17,892 ft; however, commercial production failed to hold up.

★ **Heavy California development program** recently inaugurated by Union Oil Company in the Guadalupe Field near Santa Maria has so far resulted in the addition of 12 new producing wells bringing the total daily production for the field to around 2750 bbl.

Rotary Rigs Operating in Oil Fields of United States and Canada*

	Dec. 19	Dec. 26	Jan. 2	Jan. 9	Jan. 16
Pacific Coast	148	143	140	132	131
Oklahoma	362	307	330	317	308
Kansas	207	178	167	165	166
Rocky Mountains	291	258	254	236	221
Canada	201	200	194	196	213
Ark-La-Tex	196	186	170	169	155
West Texas & New Mexico	675	641	578	538	504
Gulf Coast	700	678	654	649	655
Illinois	155	130	109	98	106
North Texas	403	363	427	386	395
	3338	3084	3023	2886	2854

*As reported to the American Association of Oilwell Drilling Contractors by Hughes Tool Company.

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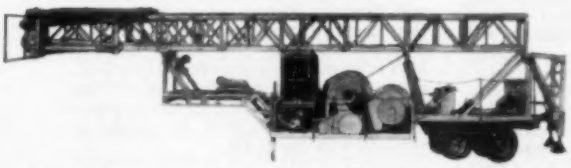
MOGUL *Torcair* 42 Single or Double Drum Winch

CAPACITY: SERVICING WELLS TO 10,000 FEET With 2½-Inch Tubing, Without Hydromatic Brake — **SERVICING WELLS TO 16,000 FEET** With 2½-Inch Tubing, With 15" Double Rotor Hydromatic Brake . . . **AND NOTE THESE: • FULL AIR CONTROLS • FULL OIL BATH CHAIN DRIVES • LOWER DRUM BRAKE RINGS 42" x 8½" • WILSON QUALITY THROUGHOUT • TORQUE CONVERTER APPLICATION —**

Either a Torcon Torque Converter, Twin Disc or GM Converter can be used with any single engine Torcair Rig or Winch.



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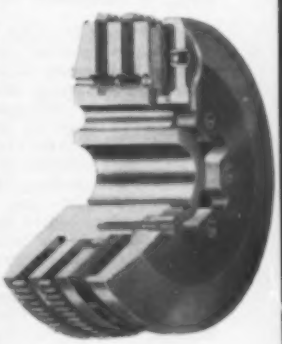
ALL DRIVES EQUIPPED WITH

WICHITA AIR-TUBE DISC CLUTCHES



This type of clutch combines all the advantages inherent in air operation, such as convenient remote control, small manual pressure required for full torque, smooth starting and controlled torque. In addition, it gives freedom from self-engagement or reduced capacity, due to centrifugal force; and has much greater torque capacity than radial type air clutches. No packing to leak or let water or oil into the clutch friction surfaces. All air connections are on the outside and easily accessible. This without a doubt the finest clutch yet developed for this type service, providing great capacity in minimum space, no adjustments, practically impossible to burn up. **SMOOTHEST ENGAGEMENT OF ANY AIR CLUTCH!**

HYDROTARDER BRAKE APPLICATION

HYDROTARDER: The Mogul unit can be equipped with the 15" Double Rotor Type Hydromatic Brake driven by a chain drive from the countershaft. This brake can be used with either upper or lower drum, and when used on main drum with five lines strung up will absorb a total of 1300 H.P. when dropping the stands at the rate of 60 feet in 12 seconds. This is the equivalent of 16,000 feet of 2½" tubing. The brake is so arranged that it will absorb very little power when taking up the empty blocks and jaw clutch does not need to be disengaged to take up the empty blocks when the trip is completed.

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RUNNING TOUR with MEN in the INDUSTRY

A. V. Hill

▸ **Ardle V. Hill** has been made manager of Drilling & Exploration's Iranian operations, with offices in Teheren. He is a long time employee of the company and was drilling superintendent in charge of the Netherlands Drilling Company, a subsidiary of Drilling & Exploration.

▸ **Castle J. Harvey,** head of Texas Pacific Coal and Oil Company's geophysical department since 1953, has become assistant manager of exploration, and **Paul C. Reed** is now TP's chief geophysicist. Harvey has

C. J. Harvey

P. C. Reed

been active in oil exploration since 1933. He was graduated from the University of Illinois with a BS in geology. Reed has been a geophysicist for Forest Oil Corporation in Midland for the past 5 years. Prior to that time he served with other companies for 16 years. He holds a BS in petroleum engineering from the University of Oklahoma.

▸ **J. E. Finley,** Midland, Texas, has been promoted to the newly created position of division exploration manager for Continental Oil Company. Formerly division geophysicist, he will continue to make his headquarters in Midland. Finley joined Continental in 1948 after graduating from the University of Missouri, where he majored in geology. **Wade E. Thomas,** Midland, division land superintendent, has been promoted to the newly created position of assistant land superintendent of Conoco's southwestern region, with headquarters at Fort Worth, Texas. **R. B. Smith,** Midland, assistant division land superintendent, has been promoted to Midland division land superintendent, succeeding Thomas. **E. E. Fickinger,** Midland, geophysical supervisor, has been promoted to Midland division geophysicist, succeeding Finley. Thomas joined Conoco's land department at Evansville, Indiana, in 1950. Smith became associated with Conoco's land department at Midland in 1951 following nine years service with another oil company. Fickinger joined Conoco in 1947.

▸ **William W. Walmsley** has been appointed assistant division manager of Sun's Rocky Mountain division.

He began work with Sun in 1951, as district landman at Billings, Montana, and was made agent and attorney-in-fact early in 1955. Walmsley attended Colgate University and received his BS degree from Rutgers University.

▸ **John E. Reed** has been appointed personnel manager of Shell Development's exploration and production research division, Houston. In his new position, he will also coordinate the personnel functions of the technical services division of Shell Oil Company. Reed attended Albion College and joined Shell at Tulsa, Oklahoma, in 1934. His latest assignment has been as personnel supervisor of Shell Oil's area office in Denver.

▸ Establishment of a new Continental Oil Company district production office at Plainville, Kansas, and one at Oklahoma City, Oklahoma, and reorganization of the company's production department in Kansas and Oklahoma have been announced. Construction of a new Conoco office building at Plainville was expected to be completed by February 1. Temporary headquarters have been located in the Conoco area office at Palco, Kansas.

L. E. Powell, former area foreman at Palco, has been promoted to district superintendent at Plainville and **K. J. Querry,** Palco, has been named district chief clerk. Production foremen who will supervise the new Plainville district's field operations in northwestern Kansas will be **O. K. Alkire,** transferred from Lyons; **W. E. Henry,** Jennings; and **H. S. Hudson** and **J. W. Thomason,** both of Palco. Others transferred to Plainville to complete the new district office staff will be **J. J. Lehman,** Great Bend; **J. D. Morrow,** Jennings; **D. C. Phillips,** Susank, and **R. G. Wilson,** Palco. In addition to establishing the new district office at Plainville, Conoco will rename its former West Kansas district the "Great Bend district." The former East Kansas district will be renamed the "Lyons district," with district offices continuing at Geneseo.

D. W. Matthews, formerly assistant district superintendent at Ardmore, Oklahoma, has been promoted to superintendent of the newly created Oklahoma City production district. **H. B. Steves,** Wichita, Kansas, has been named district engineer, and **C. C. Yeakley, Jr.,** Oklahoma City, will be district chief clerk. Also transferred to the Oklahoma City staff will be **E. R. Butler** and **W. H. Smith,** both of Edmond; **J. M. L. Bartrug** and **G. D. Mason,** both of Ponca City; **J. D. Terry,** Healdton, and **W. W. Poimboeuf,** formerly of Conoco's Oklahoma City regional staff. In addition, **B. F. Comstock** and **P. G. O'Neal,** both of Oklahoma City, will serve as drilling foremen of the new district. Production foremen who will supervise the district's Central Oklahoma field operations will be **Tom Sutton,** Edmond; **A. G. Harrell,** Tecumseh, and **Edgar Whitehead, Jr.,** transferred from Ponca City. Other Conoco production changes in the state include renaming the company's North Oklahoma district to "Ponca City district" and the South Oklahoma district to the "Ardmore district."

▸ **William T. Payne,** president of Big Chief Drilling Company and of the Payne Petroleum Corporation, has been elected to the board of directors of the Liberty National Bank and Trust Company, Oklahoma City, Oklahoma. He has served as president of the general Mid-Continent Oil and Gas Association and is a former director, American Petroleum Institute.

▸ **Charles M. Powell Jr.** has been named safety director of Geophysical Service, Inc. Powell was formerly coordinator of GSI's correspondence training program, a program designed to keep field personnel abreast of technical developments in the application of geophysics to petroleum exploration. His position will be taken by **Ben F. Giles,** formerly chief of a GSI field party. Both Powell and Giles will be headquartered at the firm's Dallas, Texas, office.

Two geophysicists, who will receive their doctor's degrees from Massachusetts Institute of Technology in February, have joined the staff of GSI. Both men previously obtained field experience with GSI through its summer program of geophysical exploration field work for selected college students. One of these new staff members, **Lawrence Strickland,** has joined the research division of the gravity department, with headquarters in Houston, Texas. The other, **Milo M. Backus,** will work in Dallas, Texas, as a research seismologist in the seismic engineering department.

Aaron Cawley

R. L. Redline, Jr.

▸ **R. L. "Leland" Redline Jr.,** former chief geologist for Great Western Drilling Company, Midland, Texas, has opened an office at Midland for all forms of petroleum consultant work. He was graduated from Texas Technological College in 1948 with a BS in geological engineering and had been chief geologist for the company since 1949. **Dewey Thornton,** assistant geologist, has been appointed acting chief geologist for Great Western.

▸ **Aaron Cawley,** former reservoir engineer for Forest Oil Corporation at Midland, Texas, has joined the firm of Keller and Peterson Petroleum Consultants in Fort Worth, Texas. Cawley was graduated from the University of Texas in 1949 with a BS in petroleum engineering. Upon graduation, he joined the Honolulu Oil Corporation at Denver City, Texas, as a production engineer. In 1954, he became associated with Forest Oil.

▸ **John R. Suman** of Houston, Texas, received special tribute at the 35th annual meeting of the American Petroleum Institute in San Francisco, California in November. Suman, who retired last spring as a vice president and director of Standard Oil Company (New Jersey), and is now operating as a consultant in the Gulf Southwest, was honored by the institute's division of production with a special award in recognition of his many years of leadership in the API's standardization program. Suman, in a response, gave his thoughts on "The Past and Future of API Standards on Oil Field Equipment."

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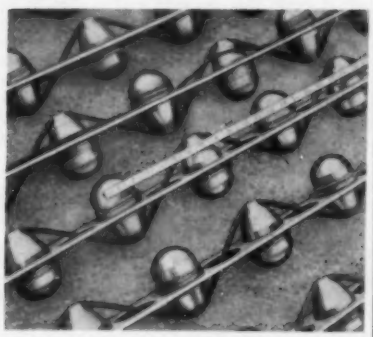
Super Casing Glass Jets Shoot 320 Holes in One Run

A McCullough Super Casing Glass Jet Perforator with Steel Strip Carrier was used to perforate an 80' pay zone at approximately 9300 feet.

Only one run in the hole was required to shoot the 320 Glass Jets, four holes per foot, through 5⅛" O.D. 17 lb. N-80 casing cemented in 9" hole.



Sections of McCullough Glass Jet Perforators and Steel Strip Carriers. After perforator is fired, the Steel Strip Carrier is removed from the well intact.

After perforating, the well came in for 210 barrels of oil and 2⅛ million cubic feet of gas per day.

Only two hours were required to complete this job, including rigging up and tearing down time.

Their ability to perforate pay zones of nearly any thickness or multiple zones in a single run in the hole, makes McCullough Glass Jet Perforators with Steel Strip Carriers of particular value to the operator.

Carriers may be loaded full length or sections may be left blank to leave unperforated areas in the casing. Steel Strip Carriers in excess of 100 feet in length have been run with complete satisfaction.

Result: Less rig time; greater efficiency; more economy.

Power Packed Glass Jets Perforate for 15,500,000 CF/D

McCullough Standard Casing Glass Jets Shoot 336 Holes in 4½" O. D. Drill Pipe Liner at 15,000'

Deep penetrating McCullough Standard Casing Glass Jets turned in a highly successful, time-saving performance in a deep New Mexico gas well, according to a recent field report.

After drilling to a total depth of 15,120 feet, 3,010 feet of 4½" O.D. drill pipe was set as a liner. The hole was full of 13 lb. mud and hydrostatic pressure at the perforating depth was 10,200 lbs.

Two runs were made with 2¾" Standard Casing Glass Jets in Steel Strip Carriers; one 45 feet in length, the other 39 feet. Tapered weights were run on the bottom of the Steel Strip Carriers to enable them to enter the top of the drill pipe liner at 12,062 feet.

McCullough Glass Jets are the best jet perforating process available. They have more power; penetrate deeper through multiple strings of casing and extra thick cement sheaths into hard and extra hard formations. Holes are larger, more uniformly round and are straight sided almost the entire depth of penetration. This means more exposed formation area, greater production, more oil!

336 Standard Casing Glass Jets, four per foot, were fired in 84 feet of zone between 14,942 and 15,026 feet.

On test, the well produced 15,500,000 cubic feet of natural gas per day—a new gas field discovery.

Several factors contributed to the operators full satisfaction with this job. First, the use of 2¾" Glass Jets in Steel Strip Carriers made it possible to run inside the restricted I.D. of the 4½" drill pipe liner and gain effective penetration through the thick walled pipe with the full power of the Standard Casing Glass Jets. McCullough Glass Jet Perforators use a more powerful shaped charge in relation to their outside diameters than any other jet perforators available.

Second, the entire job including rigging up, two round trips to 15,000 feet and tearing down, took only five hours rig time—an important saving in costs.

Third, as usual both Steel Strip Carriers with weights were removed from the well intact and no junk was left at the bottom of the hole to complicate future operations.

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LOS ANGELES
HOUSTON
EDMONTON

Running Tour

George W. Murphy, district engineer at Houston, Texas, has been transferred to headquarters office at Dallas, Texas, and promoted to assistant chief engineer for The British American Oil Producing Company. Murphy started as a trainee engineer in 1948 and progressed through the company's training program. **Edmund E. McCurtain,** staff engineer, will temporarily serve as district engineer at Houston.

British-American has announced the opening of a district office at Amarillo, Texas, with **Jack L. Stanford,** district geologist, in charge. He is being transferred from Billings, Montana, where he has been district geologist since 1954. **Jack C. Barcklow,** geologist from Oklahoma City, Oklahoma, will locate temporarily at Amarillo.

Doyle McClennen has been appointed regional petroleum engineer of Plymouth Oil Company at Midland, Texas, in charge of petroleum engineering activities for West Texas and New Mexico. He has resigned his position as petroleum engineer with Stanolind Oil & Gas Company in Fort Worth, Texas, to accept the new position. McClennen is a graduate of Texas Technological College, with a BS in petroleum engineering.

Dr. M. W. Kriegel will head the newly created production engineering section of The Carter Oil Company research laboratory, Tulsa, Oklahoma, and **L. W. Welch, Jr.,** will have charge of the new production research section. A graduate of Texas University, Dr. Kriegel has been associated with Carter's research department since 1940. Welch was graduated from Tulsa University in 1943 with a degree in petroleum production engineering and has been at work for Carter since that time.

Dr. Gordon Rittenhouse has been named manager of the geological department of Shell Development Company's exploration and production research division in Houston, Texas. He received his Ph. D. degree from the University of Chicago. Since the organization of Shell Oil Company's Denver, Colorado, area in 1954, he has been located there as coordinator of special geological studies. Dr. Rittenhouse will fill the position in Houston during the absence of **Rufus J. LeBlanc,** who will join the staff of exploration technical services of Shell Oil Company to devote full time to a stratigraphic investigation of the Texas-Louisiana coastal and offshore region. **Sherwood Buckstaff,** formerly exploration manager of the Houston area, will work with LeBlanc.

Don Anderson of Calgary, Alberta, Canada, has been named local manager of operations for Canada-Cities Service Petroleum Corporation. Superintendent of oil operations for the Canadian company the past four years, Anderson will supervise all operations of the company—including production and exploration. In his new job, Anderson assumes the exploration responsibilities of **Z. E. Stuckv,** who is being transferred to another Cities Service operation. Anderson was first employed by Cities Service Oil Company in 1930 as an engineer in the Bartlesville, Oklahoma, headquarters. He is a mechanical engineering graduate of Iowa State College and also did work at Purdue University.

J. E. Downey, formerly of Bartlesville, Oklahoma, has been named assistant division manager and division landman in the office at Calgary, Alberta, Canada, for Phillips Petroleum Company. He succeeds **L. M. Spleth,** who is now division landman of the Denver, Colorado, division. Downey, a former student of the University of Oklahoma, began work with Phillips in the refining department in 1942. Spleth was first employed by Phillips in the land and geological department in 1945 at Bartlesville.

John J. Lanigan, petroleum engineer with James P. O'Donnell, consulting engineer, New York City and Beaumont, Texas, has been promoted to senior associate engineer while retaining the post of chief engineer. **George J. Feinman** and **Edward G. Fitzgerald,** petroleum engineers, have both been advanced to associate engineer. The posts are newly created executive engineering positions.

A. L. Brown

W. F. Bates

William F. Bates has been appointed assistant to the vice president in Shell Oil Company's Pacific Coast area exploration and production office in Los Angeles, California. Bates started with Shell in 1934 as a trainee following his graduation from Stanford University as a civil engineer. In 1951, he was made production manager of the coastal division, where he has been until his recent appointment. **Arthur L. Brown** has been named the new division production manager in Ventura, California, replacing Bates. Brown joined Shell in 1939 following his graduation from Brown University as a mechanical engineer. Since 1953, he has been in charge of the production operations of the Salt Lake City, Utah, division.

Paul C. Berner has been promoted to the position of district geologist in Lion Oil Company's Wichita, Kansas, district production and exploration office. Lion Oil is a division of Monsanto Chemical Company. Berner replaces **C. Elton Gore,** who was recently promoted to regional geologist in the central region. Berner joined Lion as a geologist at El Dorado, Arkansas, in 1953, and was most recently district geologist at Salt Lake City, Utah. He was graduated from Allegheny College, with a Bachelor of Science degree and also received an MS in geology from Wayne University. **George W. Brewer Jr.,** has been promoted to district landman in the Liberal, Kansas, district office. He replaces **Jack V. Newman,** who has been transferred to Dallas, Texas. Brewer was graduated from the University of Oklahoma with a BS. In 1954, he joined Lion Oil as a landman in the Wichita district. **Bob D. Barnes** has been promoted to district landman at the Billings, Montana, office. Barnes attended Washburn Municipal University at Topeka, Kansas, from which he was graduated with BA and LLB degrees. Barnes has had wide experience as a landman in the Midwest.

C. E. Thornton has been elected president of the Canadian Association of Oilwell Drilling Contractors. Other officers are **N. Gustavson,** vice president, and **Peter Bawden, Marshall Cone, R. H. Gibbons, D. K. Gunderson, Morris Palmer and J. W. Wark,** directors.

L. E. J. Brouwer, general managing director of the Iranian Oil Exploration & Producing Company and the Iranian Oil Refining Company in Teheran, will leave Teheran toward the end of March in order to assume a position of high responsibility in the Royal Dutch-Shell Group. He will be succeeded as general managing director by a Dutch mining engineer, **K. Scholtens,** who has at present a senior position in the Bataafsche Petroleum Maatschappij, the main Netherlands operating subsidiary of the Royal Dutch-Shell Group. Scholtens has 30 years experience in producing, refining and sales branches of the oil industry.

C. E. "Dad" Wilcox, pioneer designer and inventor of oil tools, has been awarded a life membership in the Petroleum Production Pioneers. He invented the Kelly and the square bushing with a tapered bowl that permits wedge slips to be inserted for gripping the pipe. He has been responsible, however, for the development of tongs, elevators, underreamers and other tools that are now in wide use. Dad Wilcox began his oil career with the original Standard Oil Company at Maxbury, Ohio, and has since compiled a total of 70 years in the business.

Alan M. Bieber, Richard H. Fulton and **Alexander S. Wyner** have joined Ball Associates, oil and gas consultants, Washington, D. C. Bieber is a former independent geologist. Fulton was formerly with Midstates Oil Corporation and Wyner was formerly a mining engineer and geologist.

L. F. Shiplet has been appointed division manager of West Texas division, The Texas Company's producing department. Shiplet, assistant division manager, will succeed **C. B. Williams,** who has retired after 14 years as division manager, and 36 years with the company. **O. F. Sebesta,** general superintendent of drilling and production, will be advanced to assistant division manager. **J. A. Hale,** assistant to division manager, South Texas division, Houston, has been promoted to assistant division manager, West Texas division. Shiplet started with The Texas Company in 1927 as a roustabout in Maljamar Field, New Mexico. Sebesta, who was graduated at Texas A&M College with a BS in petroleum engineering, was first employed by the Texas Company as a roustabout at Houma, Louisiana, in 1938. Hale, former student of Washington University, St. Louis, Missouri, began work with the company as map boy in the Tulsa office of Oklahoma division in 1927. Williams received a degree in electrical engineering from the University of Texas. His initial assignment with The Texas Company in 1919 was assistant engineer in foreign operations in Mexico. **W. F. Herbert,** who has been in foreign service for The Texas Company for more than a year, has been appointed assistant to division manager of the South Texas division. He served until recently as manager of technical services for the Iranian Consortium, with headquarters in London, England. Herbert was graduated from Massachusetts Institute of Technology with a BS degree.

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1. PGAC's standard core gun retrieves up to 32 separately-fired barrels with cores from 1 to 32 zones — on one trip in your well.
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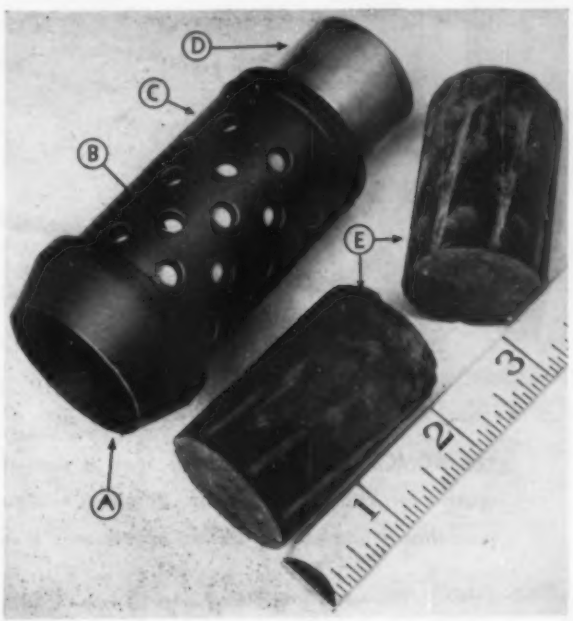
7. PGAC's flexible steel barrel-retrieving cable, of 2800-lb. tensile strength, assures barrel and sample recovery.
8. The Jumbo core gun is positioned in your formation with exceptional precision by the S.P. curve on PGAC's electrical log.
9. PGAC's surface indicator responds as each barrel is fired — eliminates re-runs in well because of undisclosed misfires.
10. Foolproof PGAC safety features prevent accidental firing — assure intentional firing only.
11. Subsequent completion operations have never been complicated by barrels or other debris left in a well cored by PGAC.
12. PGAC's Jumbo coring operation is simple, fast, certain, economical — and always ready to serve you.

PGAC 561



(Right) PGAC's 32-shot Jumbo sidewall coring tool.
(Above) PGAC sidewall coring projectile and cores: A — Cutter; B — Mud extrusion ports; C — Core barrels; D — Powder chamber and retrieving cable housing; E — Large PGAC Jumbo Cores.

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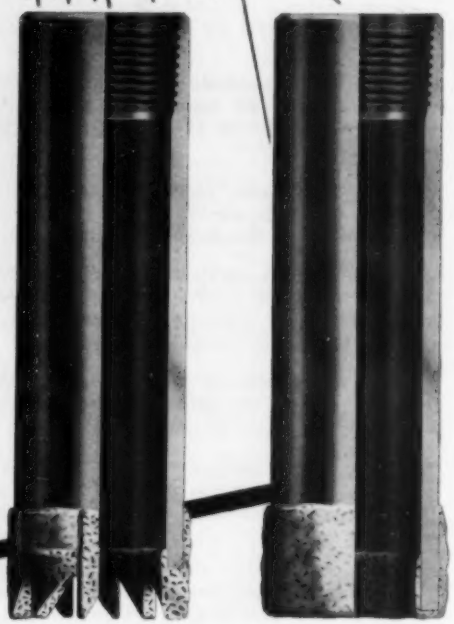
HOUSTON OIL FIELD MATERIAL COMPANY, Inc.

KLUSTRITE

Case History

1. Harvey, Louisiana—Two **HOMCO "Klustrite" Rotary Shoes**—36 hours—burned up 1 regular type rotary shoe, a piece of a box tap, part of a die nipple, a four-foot slab of 10¾" casing, 4 sets of cutter knives—and an additional 10 feet of hole was made. Hole cleaned—drilling operations resumed.

2. White Castle, Louisiana—Using a 9¼" cutting type **HOMCO "Klustrite" Rotary Shoe**, 6340 feet of hole was drilled through tight formations and anhydrite; total drilling time, 5 days.



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The *HOMCO* "Klustrite" Rotary Shoe is one of the outstanding developments in the field of wash-over, cutting operations. This tool will cut through the hardest formation and burn around junk that is hampering drilling operations. It is available in all sizes and designs.

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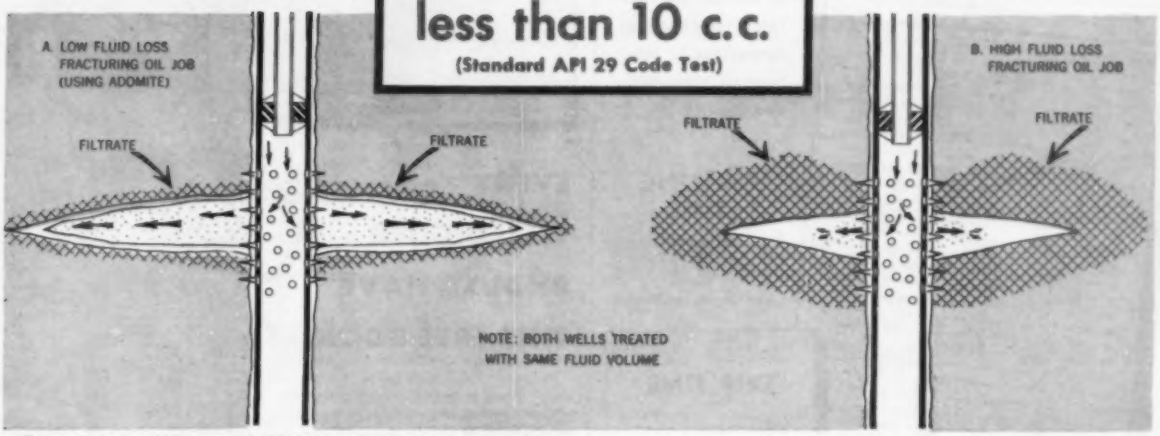
For more productive fracturing... least fluid loss

specify Adomite*

Cuts fluid loss to less than 10 c.c.
(Standard API 29 Code Test)


A. LOW FLUID LOSS FRACTURING OIL JOB (USING ADOMITE)
FILTRATE
FILTRATE
B. HIGH FLUID LOSS FRACTURING OIL JOB
FILTRATE
FILTRATE
NOTE: BOTH WELLS TREATED WITH SAME FLUID VOLUME

*Trade-mark, Continental Oil Company © 1956, Continental Oil Company

Adomite is the remarkable fluid-loss control additive that is building production and profits virtually everywhere it is used. Very small amounts of Adomite reduce the API fluid loss of lease crudes to 10 c. c. at most reservoir conditions. With gelled crudes, even smaller quantities are required. *Easy to use*, Adomite is a dry material in flake form that is mixed directly into the crude or gelled crudes on the lease. Only standard mixing equipment is required.

*Trade-mark, Continental Oil Company

Only Adomite can do so many things so effectively . . .

- Seals the fracture face—minimizes fluid loss.
- Longer fractures—deeper penetration of sands.
- Greater sustained production with a given fluid volume at lower cost.
- Saves you money—utilizes lease crudes—less pumping.
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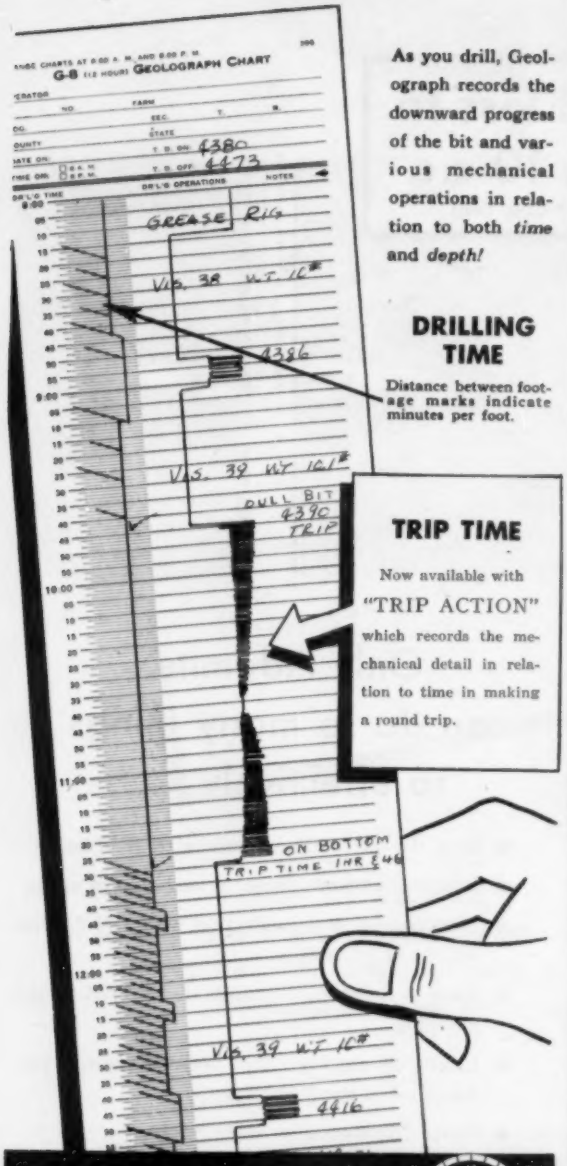
- Fewer "Sandouts."
- Profitably used for "drilling in" and "work overs."

Be sure to specify Adomite on your next fracture job

GEOLOGRAPH'S permanent record helps *eliminate guesswork!*



As you drill, Geolograph records the downward progress of the bit and various mechanical operations in relation to both *time* and *depth!*

DRILLING TIME

Distance between footage marks indicate minutes per foot.

TRIP TIME

Now available with "TRIP ACTION" which records the mechanical detail in relation to time in making a round trip.

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This new Martin-Decker booklet contains a wealth of information about drilling-control instruments vital to every driller, toolpusher, engineer, oil operator, and contractor. This is not a mere catalog of gauges for sale, but a genuinely instructive handbook that, with photographs, schematics, and non-technical language, explains the workings of instruments and the parts they play.

Write for Bulletin P-61, Martin-Decker Corporation, 3431 Cherry Ave., Long Beach 7, Calif.

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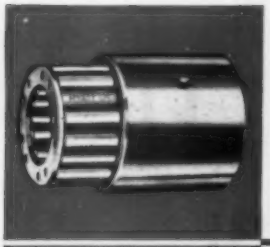
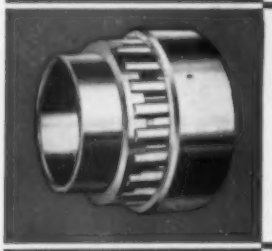


TRUNNIONED ROLLER CAGE—Economical for volume use on thin-annulus bearings. End rings are hardened steel stampings, connected by riveted bars interspersed between rollers to form an integral unit. Races can be omitted if desired.

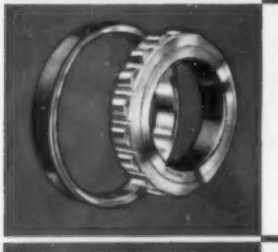


POCKETED END RING CAGE—Designed for fairly large bore bearings in heavy-duty service. Rollers are guided accurately by pockets drilled in bronze end rings. Riveted connecting bars form an integral unit, so races can be omitted if desired.

STAMPED STEEL SEPARATOR—Economical for volume use on wide range of bearings with short rollers. A single steel stamping with bars coined to conform to roller contour. Simple, open design assures large lubricant capacity and good circulation.

FORMED BAR CAGE—Well adapted for volume use on heavy-duty bearings. Hardened steel end rings are connected by cold-rolled shaped bars conforming to roller diameter. Insures quiet operation, better roller guidance, and the smooth surface of bars protects rollers.

DRILLED POCKET CAGE—Used on better-grade bearings to provide extremely close control of rollers, which operate in pockets drilled and reamed in bronze cylinder. Riveted ring on one end retains rollers permanently, so races may be omitted if desired.



SEPARABLE BROACHED POCKET CAGE—Used only on finest high-speed bearings. An integral bronze cylinder with pockets broached for maximum uniformity. Insures minimum friction, better oil circulation for cooling. Rollers can be removed for inspection.

NON-SEPARABLE BROACHED POCKET CAGE—Similar to the above and offers all the same operating advantages. Used for "blind" installations where rollers must be retained with inner or outer race. Roller drop controlled by deforming bars after rollers are placed.

What makes a cylindrical roller bearing good?

When you buy a roller bearing, you expect it to do a certain job for you. How well it does that job depends on many different factors. This series of messages is designed to help you recognize some of these important differences and get more for your bearing dollar.

The RIGHT KIND OF RETAINERS for the application

The basic parts of a roller bearing are the rollers, the races, and the *retainer* which locates and guides the rollers. There are significant differences in the design and construction of retainers, which influence bearing cost and performance. Some are simple and economical, well adapted for volume production; others are more costly but insure improved roller guidance, or cooler and smoother operation, or longer heavy-duty service. The seven basic types in current use are illustrated.

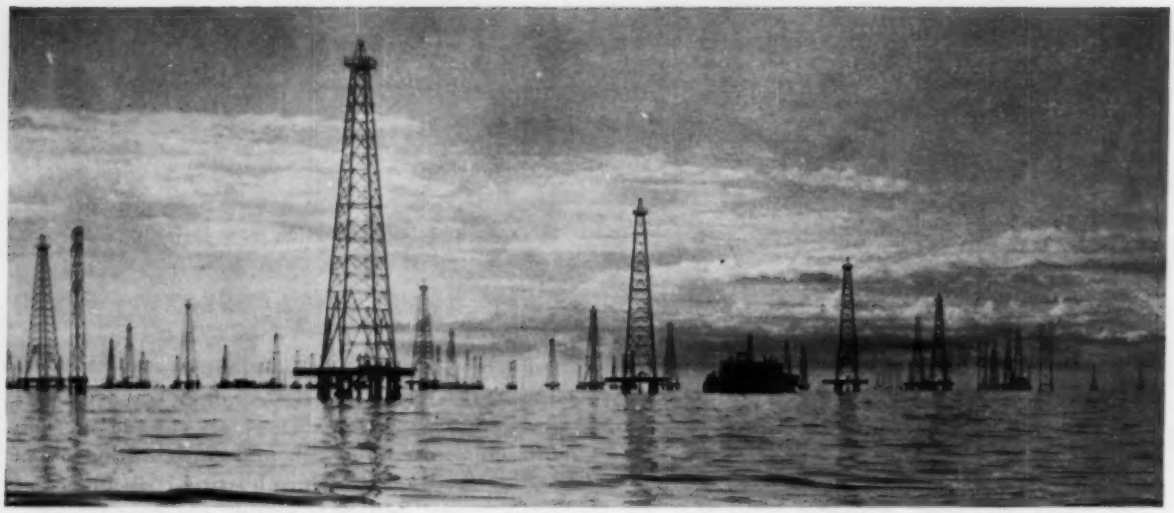
HYATT MAKES ALL SEVEN TYPES . . . EACH THE FINEST OF ITS KIND! You will find complete details in HYATT General Catalog No. 150, or your nearby HYATT Sales Engineer will gladly help you choose the type best suited to your requirements. Remember, HYATT is America's *first* and *foremost* maker of cylindrical roller bearings. Hyatt Bearings Division of General Motors, Harrison, N. J.

GM GENERAL MOTORS

HYATT ROLLER BEARINGS

First field report:

MUD COSTS CUT $2.18 PER FT. IN OFFSHORE WELL WITH DU PONT CMC GRADE DM ADDED



USE OF GRADE DM in a variety of sea-water muds proves it much more economical than refined CMC. Grade DM resists contamination from high concentrations of salt and anhydrite . . . keeps fluid loss low . . . reduces mud viscosity.

Du Pont CMC minimizes fluid loss . . . reduces mud viscosity at much lower cost than refined CMC

Substantial savings on mud costs—more than 50% in some cases—and low mud viscosity are two reasons why Du Pont CMC Grade DM is an unqualified success in its first extensive use as a drilling mud additive.

For example, one company drilled three wells to an average depth of 8,200 feet each in the same offshore field, using Du Pont CMC in one and refined CMC in the other two. Mud costs with Du Pont CMC were $2.12 per foot, while costs in the other two wells were $4.30 and $4.17, respectively. Fluid-loss control was comparable for the three wells and the excessive mud viscosity commonly incurred with refined CMC was not encountered in the well using Du Pont CMC.

Similar cost-cutting experiences are reported for land wells, and with the same excellent control of fluid loss. Versatile Du Pont CMC can be added to lime-treated mud to avoid high mud viscosities often caused by starch . . . or to sea-water mud systems to thin out the mud. High-temperature wells are no problem —Grade DM resists thermal and bacterial degradation. Try it the next time you drill and benefit from its economy and performance.

Ask for Du Pont CMC Grade DM from your mud dealer, or locations of Macco Corp. and Barada & Page, Inc., or from E. I. du Pont de Nemours & Co. (Inc.), Explosives Dept., Wilson Bldg., 1621 Main St., Dallas, Texas, or Chemical Sales, Wilmington 98, Del.

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Fast penetration, full core recovery.

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CORE BARRELS
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Drilling & Service has long been the industry's leader in the manufacture of quality core barrels. Field-proved and tested, D&S core barrels meet and surpass all oilfield requirements. Years of research and experience are built into each. Check these D&S advantages: Longer core runs are possible and fishing jobs are simplified. Faster penetration in soft or hard formations mean *more* overall rig savings! Specially rolled tubing is an added safety factor. Full circulation, elimination of core washing, and less core friction and wedging are assured. D&S core barrels give you connection every time and core recoveries not affected by formation changes.

Write or call today! One of our sales engineers will call on you and explain our custom-services and equipment. Herein lie the real D&S advantages.

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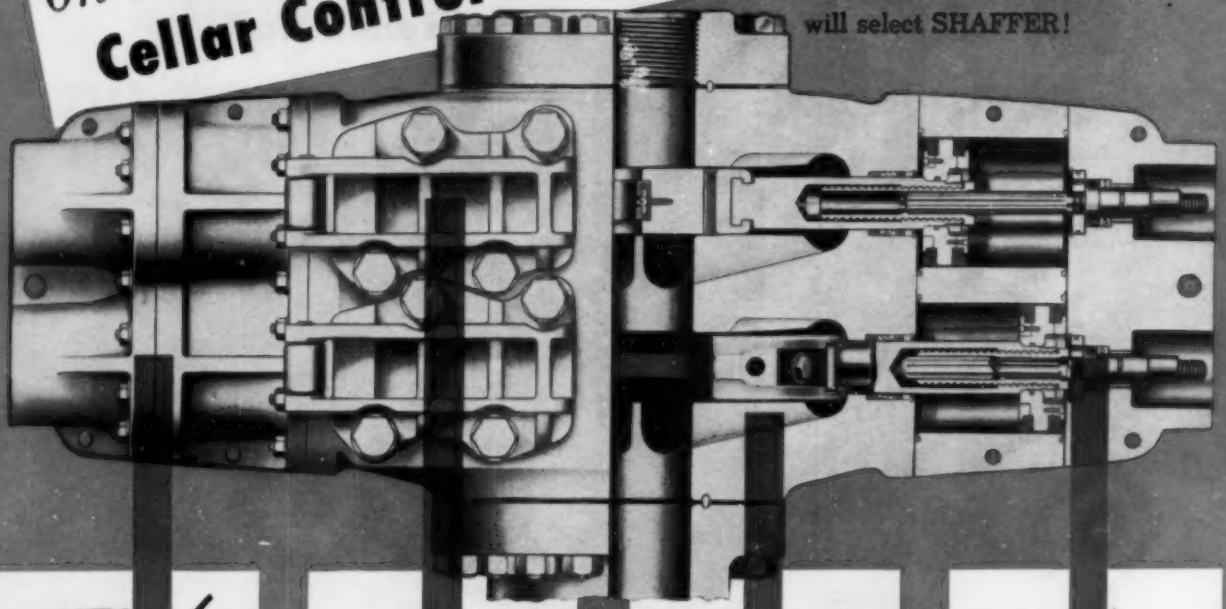
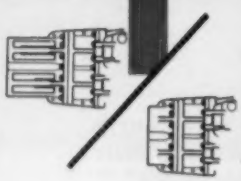
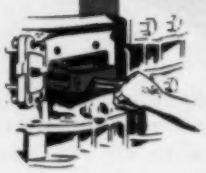




Rising or Non-Rising Stem

Some operators like the extra compactness of a non-rising stem on the locking screw—others prefer the quick indication of ram position afforded by a rising stem. Take your choice—Shaffer, and **only** Shaffer—provides your choice of whichever design **you** prefer. Note that built-in body extensions guard each stem in all positions. The stem—whether rising or non-rising—is never exposed beyond the body where it might become bent or damaged.

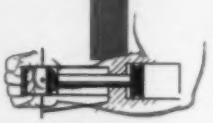


Simple Ram Changes

To change rams in Shaffer Hydraulic Gates you simply unbolt and swing open two side doors, slide out the ram assembly, change rams, replace the assembly and bolt the doors. Closing the doors automatically aligns the rams within the gate body. And whether pipe is in or out of the hole, rams in **either** compartment can be changed with equal ease. There's no need to dismantle the upper compartment to change rams in the lower compartment—or vice versa!

Mud-Free Drainage

Shaffer rams travel on high, narrow guide ribs above the steeply-sloped ram compartment bottoms. Mud and sand quickly drain back into the well—leaving no detrimental accumulations to interfere with free opening and closing of the rams. This assures quick, easy ram operation and simpler maintenance. In addition, since well pressure is free to flow to the back side of the rams, it actually assists in the closing and sealing action of the rams.



Direct Hydraulic Drive

In Shaffer Gates there are no yokes or complicated secondary connections between rams and operating pistons. The hydraulic cylinders are **directly behind** the rams for positive action, fewer parts, simpler maintenance. And whether you select rising or non-rising stem design, you get the same fool-proof operating principle on the hydraulic drive.

...And maximum Compactness, Too!

To advantages such as those outlined above add the fact that Shaffer Hydraulic Gates require a minimum of space—in length, width and height—and you have another Shaffer "plus." Even in sizes as large as 13⅝" (12" Series 900) Shaffer Hydraulic *Double* Gates require only 30" total height—*Single* Gates only 18½". *And no extra room is needed at the top or ends to allow space for making ram changes!*

There are many other Shaffer features that assure far more for your pressure-control dollar. Get full details from your nearest Shaffer representative—or write direct!

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• ECONOMICAL, STURDY, AND DEPENDABLE BEAM-BALANCED PUMPING UNITS . . .

• Where **ECONOMY** is an important factor, and **DEPENDABILITY** is a prime consideration . . . THE LUFKIN Type B Unit is the answer

• **AVAILABLE IN THE FOLLOWING SIZES:**

B—10 D—20—4
B—16 DA—22—5
B—16 DA—30—5
B—25 D—24—6
B—40 D—34—8
B—57 D—42—10.5

• EXPLANATION OF UNIT DESIGNATION . . .
B—FOR BEAM COUNTERBALANCE
10D—GEAR REDUCER—(10,000 IN. LB. PEAK TORQUE—DOUBLE REDUCTION)
20—MAXIMUM STROKE—(20 INCHES)
4—PEAK POLISHED ROD CAPACITY (4000 LB.)

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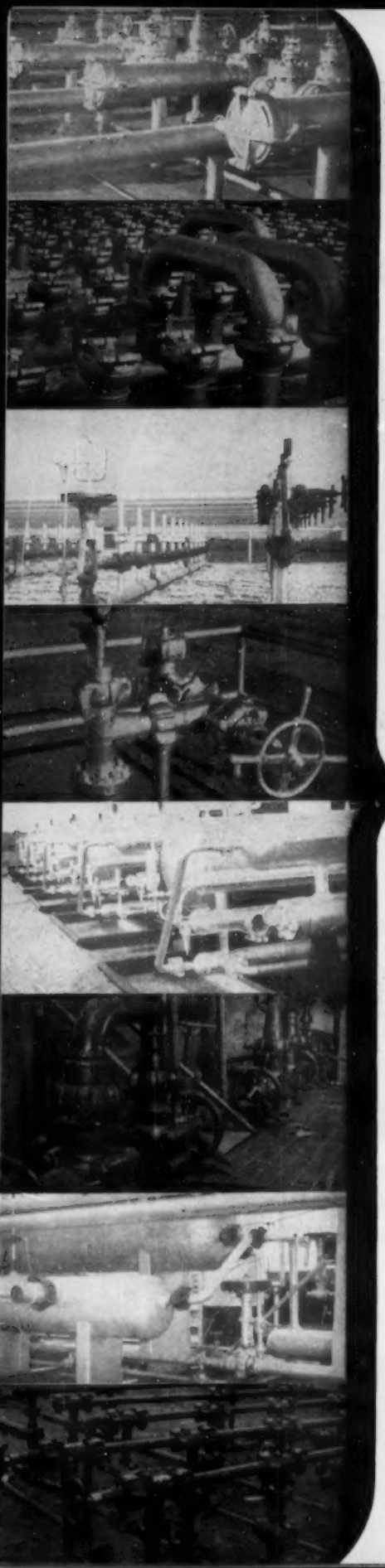

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Distinctive features: **Lighter but stronger**—its unique design results in minimum bulk and weight yet places more metal in shear to provide greater strength. **One bolt**—simplifies assembly and disassembly and serves only to draw tapered interlocking shelves together, carrying none of the load of the coupling itself. **Adaptability**—its design readily permits adapting it to numerous fittings, as well as pipe couplings. **Interchangeability**—any part for a given size and type coupling or fitting is interchangeable, permitting minimum warehouse stocks of UNIBOLT products and replacement parts. **Broad field of application**—ALL UNIBOLT products utilize the same basic mechanical design, only the seal rings, or gaskets, differ with the class of service.

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Loading of a 171-ton Bubble Tower fabricated at the Beaumont Yard. ▼

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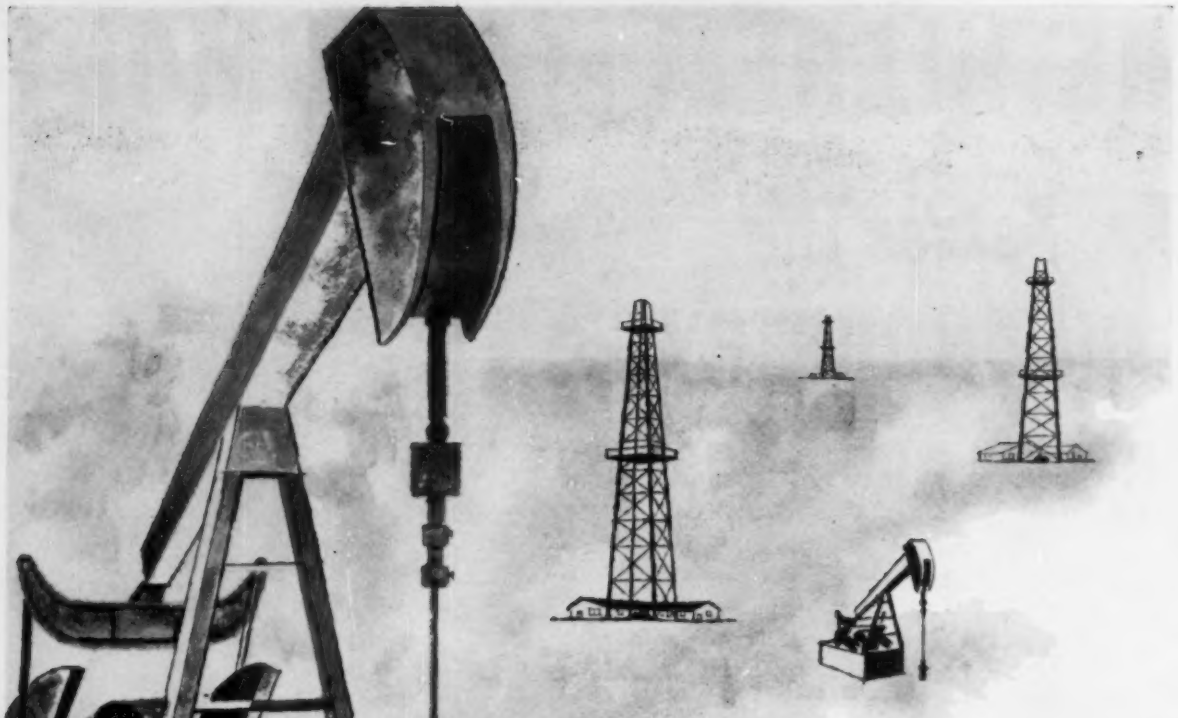

AMPCO* METAL quadruples life of polished rod liners

Critical part sets new records in tough oil-well service, thanks to Ampco Metal's remarkable corrosion- and sliding-wear resistance

In oil well pumping the 14 to 16-foot polished rod liner really takes a beating. As you can imagine, sliding wear, in this extra-long bushing, is a real problem when you consider the number of strokes made by a pump during an operating day. Corrosion enters the picture, too, with the liner often in contact with salt water, sulfides, etc.

With ordinary bronzes, Cities Service Oil Company found frequent replacement to be a constant headache. Then, in certain areas, it switched to liners made from Ampco Metal Pipe. Cities Service engineers report a substantial reduction in liner replacements.

Ampco Metal Liners last four times as long as plain bronze liners because they are made from a unique aluminum bronze alloy. It's a remarkable bearing material—has unusual resistance to mechanical wear. It withstands the corrosive effects of many acids and caustics. And when used as pipe it combats erosion from solids held in suspension.

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AMPCO METAL, INC.
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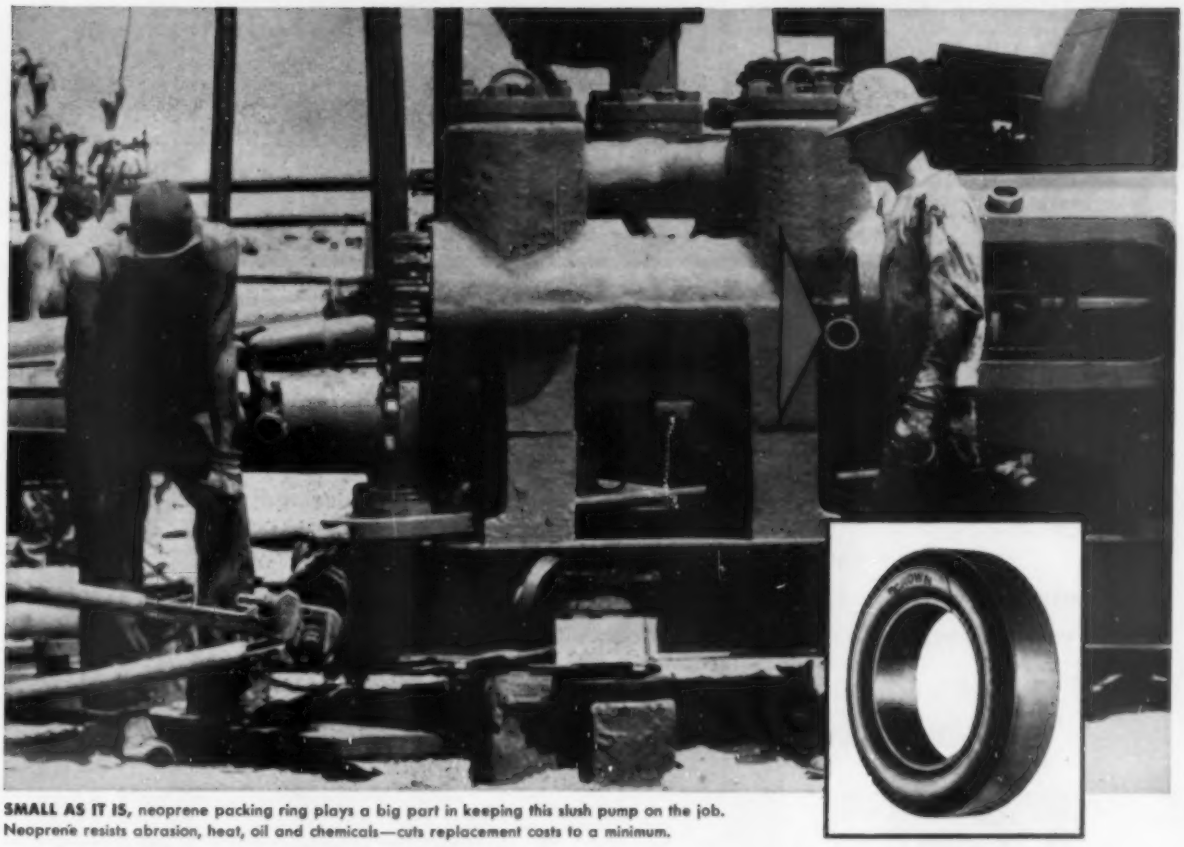

SMALL AS IT IS, neoprene packing ring plays a big part in keeping this slush pump on the job. Neoprene resists abrasion, heat, oil and chemicals—cuts replacement costs to a minimum.

"Neoprene packing rings really stand up —last twice as long as ordinary rings!"

—says Dan May, Tool Pusher, Big Chief Drilling Co., Oklahoma City, Okla.

"Believe me, the slush-pump packing you use sure can make a difference in downtime and drilling costs. That's why we always install neoprene packing rings. We've found they last twice as long as ordinary rings!

"Right now, we're on a hole near Andrews, Texas—a real tough one. The three neoprene rings on the piston rod are subjected to 2200 lbs. pressure and abrasion from the piston rod. We've pumped plenty of oil-base mud, and there's a lot of oil on the piston rod, too. But neoprene rings stay strong and flexible and keep delivering."

Packing rings are only one of the many neoprene products drilling firms are using to get the most out of their equipment. So next time you're buying piston rubbers, pipe wipers, rotary drilling hose or gaskets . . . any resilient products at all . . . specify NEOPRENE.

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This new hydraulic chain feed drill features fewer, more conveniently grouped controls. It combines the speed and simplicity of the chain feed drill with traditional Failing mobility, ruggedness and safety.

The Roller Chains for feed as well as mud pump and sub drives are Diamond.

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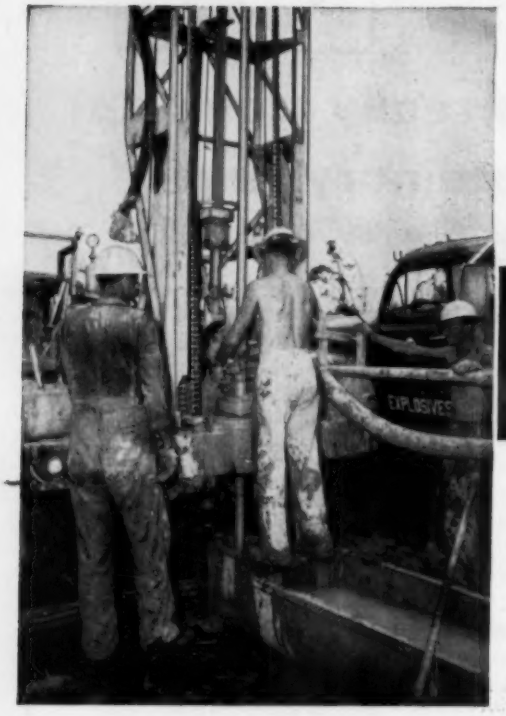

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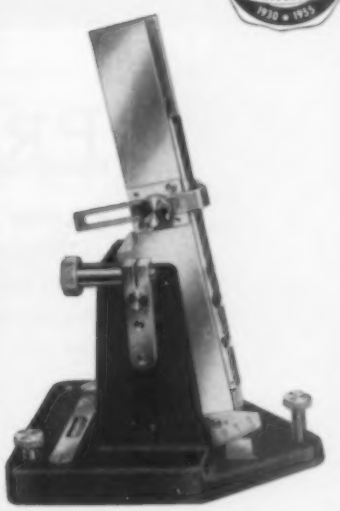

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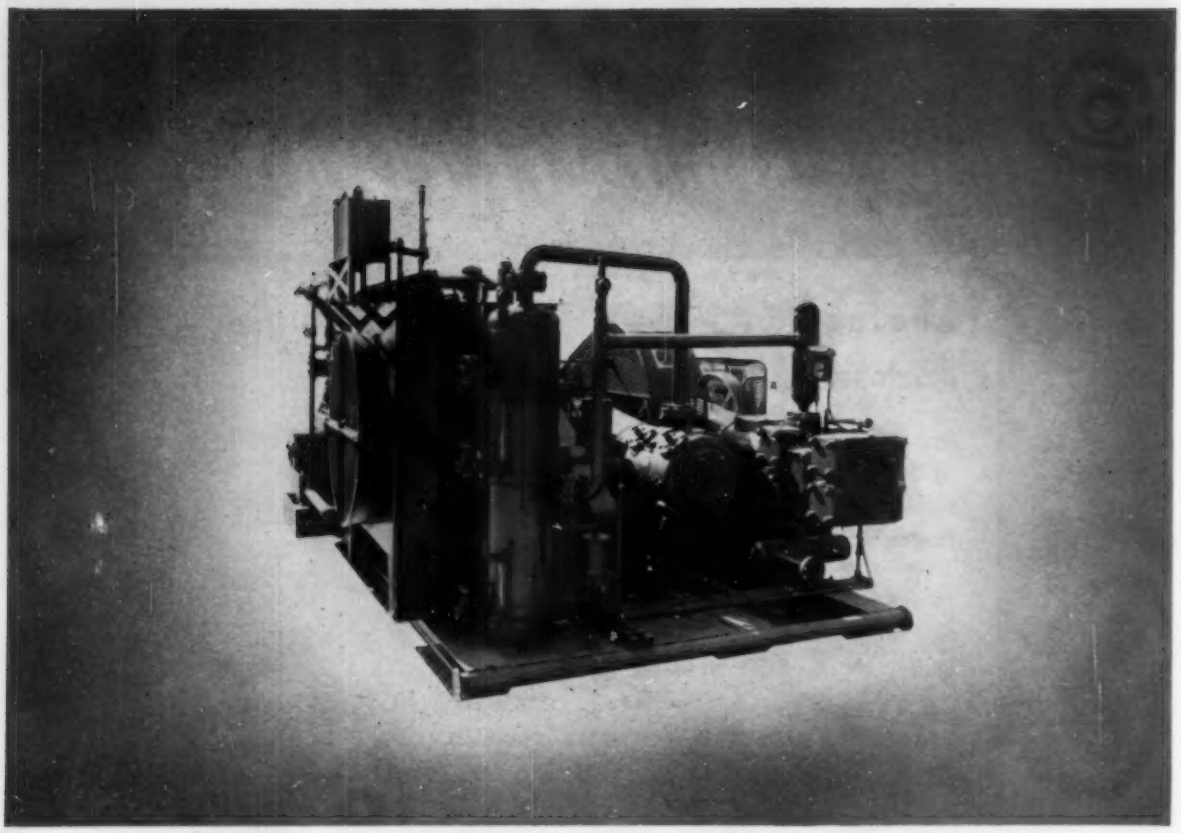

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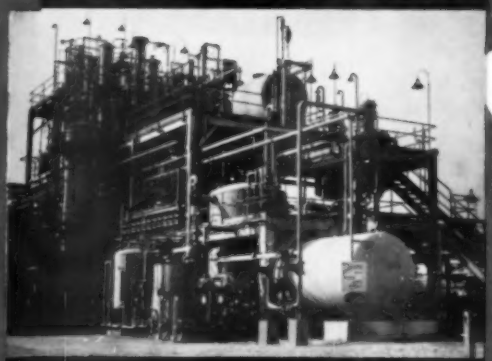

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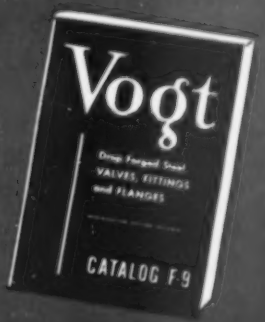
There are good reasons behind the trust which America's key industries have placed in Vogt valves, fittings, and flanges for half a century. They know that *drop forged materials* are uniform in structure, fine grained, and free from porosity. They know, too, and appreciate the meticulous care given these products through every stage of forging and machining in Vogt's modern shops, and about the many rigid tests and inspections. And that is why these products enjoy such an impressive record of performance in withstanding the shocks and stresses imposed by high or low pressures and temperatures and in resistance to erosive and corrosive conditions.

Service is another important factor in this confidence because Vogt maintains the world's largest and most complete stock of drop forged steel valves, fittings, and flanges always ready for immediate shipment.

Write for Catalog F-9. Consult its 400 pages for the complete Vogt line of drop forged steel valves, fittings, and flanges for oil, steam, water, air, gas, and refrigeration services. Address Dept. 24-PPE



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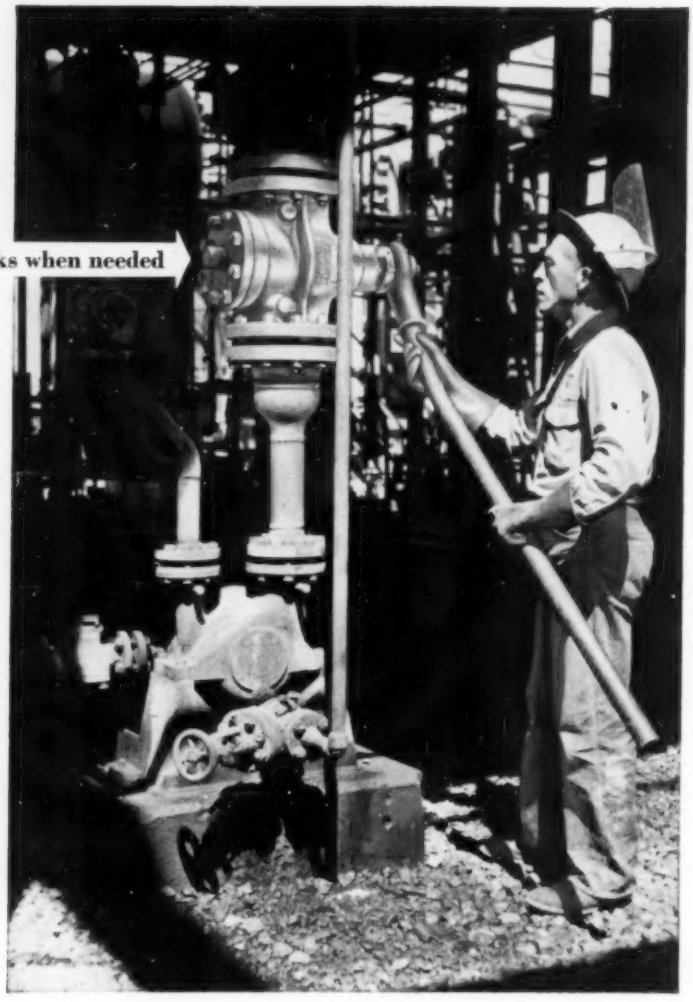
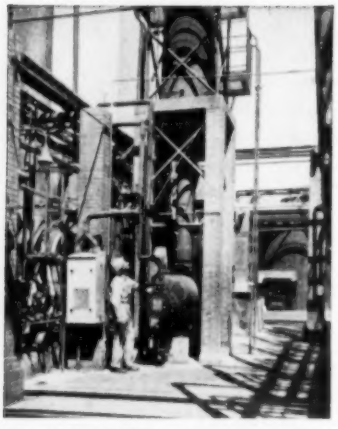


***Monel-lined HF valve* works when needed**

Monel-protected HF alkylation plant runs safely on non-stop schedule



Monel-lined HF regenerator resists HF concentrations up to 92% at temperatures to 280°F and pressures to 80 psi.

When to consider Monel for HF alkylation equipment. Monel nickel-copper alloy provides useful resistance to HF in all concentrations and (in unaerated solutions) up to 250°F. It is used with the anhydrous acid at temperatures up to 1100°F. Monel is comparatively unaffected by high stream velocities. Its strength and wear resistance is high.

INCO Nickel Alloys

Imagine the fire-works if a high octane plant *couldn't* be shut down!

When Continental Oil's Ponca City refinery was constructed during World War II, HF alkylation was new. But gasoline was desperately needed. So even before materials research could be completed, plants had to be built.

Valves were the trouble-makers. Corrosion plus internal stresses cracked them. And corrosion product build-up on critical valving surfaces interfered with operation.

Continental solved this fast. With Monel* nickel-copper alloy welded overlays. (Later they put in solid Monel alloy valves.)

Silver lining goes next

The next thing to go was the silver lining of the acid regenerator. Here sulfur-laden 85-87% acid at 280°F. and 80 psi is present. In 1945, Monel alloy was tried. That did it. Now, tower lining and reboilers, condenser and adjacent piping are all Monel. So are unique liquid level probes within the reboilers. So are relief valves, pump seals, bolts, and acid-propane fractionating tower trays.

*Registered trademark

Now operates non-stop

Today, Continental runs its alkylation units as long as twelve months at a time. Without a halt. Safely. The company estimates Monel saves from 15 to 25% over former operating costs.

Are you having difficulties traceable to HF corrosion? Put the problem up to Inco's Corrosion Engineering Section. You'll get practical help.

The International Nickel Company, Inc.
67 Wall Street New York 5, N. Y.

Monel... *for minimum maintenance*

NEWS and COMMENT

Scientists – Fuel Pumps – Atom Smashers – Automation

PREMIUM MOTOR FUELS at year's end showed a weighted average octane number of 96.1 with 88.9 for regular or housebrand grade, Ethyl Corporation has found in its December, 1955 survey. This premium grade rating is 1.8 octane numbers higher than December 1954; regular was 1.6 numbers higher than a year ago. This survey represents 850 samples bought by Ethyl employees at service stations in 53 cities and towns. More than half the cities showed octane number rises, and the whole picture shows the slow but inexorable climb in anti-knock quality, brought about by free competition among refiners.

★ ★ ★

COMPARATIVE LIQUID ANALYSIS program of samples of hydrocarbons of known composition has been announced by the Natural Gasoline Association of America, and Sample No. 7 will be distributed soon to 102 companies and commercial laboratories in the U. S. and Canada. It will contain no ethane, but is blended by Phillips Petroleum Company with all hydrocarbons from propane to hexanes-plus. Laboratories wishing to check their own results are invited to participate. A. J. Miller of Phillips Petroleum Company, Bartlesville, Oklahoma, is chairman of the NGAA Analysis Subcommittee handling the program.

★ ★ ★

THE ROTOSORBER, a new process for removing hydrocarbons from casinghead gas, has come along. Nothing is known here of the details of the process, which has been tested for more than a year. Is coming up to final pilot plant rating soon: Process owner, Jefferson Lake Sulfur Company.

★ ★ ★

LEARNING HOW ENGINES and fuels behave is becoming more and more nearly an exact science. Two Ethyl Corporation researchers, J. A. Warren and J. B. Hincamp, disclosed their development of the Crank Angle-Time Recorder, a device that shows the time or point in the engine combustion cycle when erratic or "wild" combustion occurs. It consists mainly of a crankshaft-driven rotating drum on which a special paper is rolled and on which a dot is made electrically each time the instrument is "triggered" by a combustion event, through an activating device such as the Surface Ignition Counter. The dots show the crank angle, that is, the point in the rotation of the crank when the unusual combustion occurs.

★ ★ ★

ORGANIC SILICONES are being made available by Linde Air Products Company, which has developed the announced six such compounds, indicated by the names of X-520, X-521, etc. These products are recommended for many applications, as in rubber, plastics, cosmetics, lubricants for high temperatures, greases, etc., and specialties such as emulsifying and demulsifying agents, defoaming, etc.

★ ★ ★

PLASTIC PIPE AND TUBING may be in for a great big run, if the first demonstration, held by National Tube at its Odessa, Texas, plant, is any gage. Laying 2800 ft of 2-in. pipe in slightly more than 100 min — 90 joints — this polyvinyl pipe is 3500 ft total length, was hauled on a single truck and weighs a ton.

★ ★ ★

ALL PETROLEUM FUELS and lubricants needed by the Dr. Vivian Fuchs-led British trans-Antarctic Expedition are being supplied at its own expense by British Petroleum Company, following a six-month testing period when all sorts of products were tested to meet conditions of temperature as low as —90 F. Made and assembled at the Isle of Grain refinery, they were put aboard the exploration ship "Theron" at London, for the start in mid-November.

★ ★ ★

STOCK OF JOHNSON OIL Refining Company has been sold, reports say, to "an Oklahoma City firm," although no name has been disclosed and the two Oklahoma City oil companies that might be interested state that they are not involved in any way in the deal. With a 6500 B/D refinery at Cleveland, Oklahoma, and the main business office in Chicago, Illinois, the company is owned largely by one family and by its employees. Report states that $24 per share has been given for 53 per cent of the 25,000 shares outstanding. Investment bankers Blair & Company of Chicago are handling the transaction.

SMOG CAN BE REDUCED by as much as 35 per cent at sulfur recovery plants by the continuous use of the mass spectrometer in analyzing the contaminants found in the air. Also, as much as 1.2 tons of sulfur per day were recovered that formerly went to contaminate the atmosphere.

★ ★ ★

ATLANTIC REFINING'S petrochemical division is said to have been dragging its feet in development in petrochemicals. Explanation — caught in squeeze between boosted crude prices and lowered products prices. Atlantic produces only slightly more than half its crude requirements. Company spent $30,000,000 for exploration in '55, and will keep on along this line, believing it will pay off in the long run.

★ ★ ★

IRAQ'S FIRST REFINERY American designed and built, and American managed, is on stream these last few weeks, to run 24,000 bbl of local crude daily. Built by M. W. Kellogg it makes gasoline, kerosine, light gas oil and diesel oil, also residual (heavy) fuel oil from a single combination unit, which includes vis-breaking, thermal cracking and reforming, and a plant for making and reclaiming sulfuric acid. Most of the construction crews were Iraqi's, trained in their work in special schools. Can shop will make and fill, daily, 15,000 "Standard Oil Cans," famous for all purposes throughout the Near and Far East.

★ ★ ★

EXHAUST GASES and their relation to smog and air pollution is to be studied by the U. S. Bureau of Mines with the aid of the Public Health Service including a $98,000 grant from that service to the bureau to defray expenses of the research. The Weather Bureau and the National Bureau of Standards will work on the problem concurrently, also. The program is to last for five years, and gases from automobile and truck engines will be studied in the light of different lubricating oils and fuels to determine the effect of differences in the materials on air pollution, if any difference can be found. This phase of the work will be carried out in Bartlesville, Oklahoma. Another phase, dealing with trash and garbage incinerators, will be carried out at the main station in Pittsburgh, Pennsylvania.

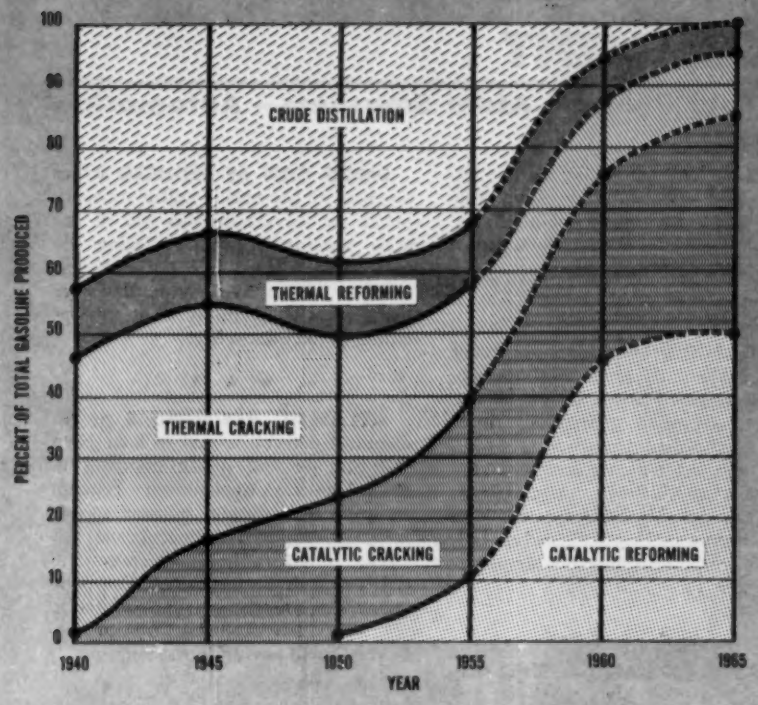


FIG. 1. Trends in processes for making gasoline. By 1965 catalytic reforming may account for 50% of all gasoline.

How to get your top octanes more economically

By HAROLD J. GIBSON
Ethyl Corporation, Detroit, Michigan

WITH the growing trend to better-grade gasolines, the cost of producing those last few octane numbers has steadily increased. As a result, refiners are looking anxiously for more economical ways to get their top octanes.

Already octane numbers in the 97 to 98 range are being marketed in the East and Southwest. And the trends for all U.S. refineries in terms of pool, regular and premium fuels show that octane numbers are continuing a slow, steady rise each year.

To meet the demand for higher-octane fuels, refiners are being constantly forced to change their processes. A look at the graph at the top of the page (Fig.1) will show you the gradual changes in process evolution. Note that by 1965 catalytic reforming may account for 50% of the total gasoline production in the industry.

Depending on the specific octane-improvement problem, the economic answer usually consists of a combination of tetraethyllead and various processing steps. (Some of these processing alternatives are displayed in Fig. 2.) The question becomes: How to determine the most economical way to get those top octanes. Only by conducting a detailed economic analysis can a refiner be sure of finding the best solution for his refinery, for from an economic analysis he can determine the proper balance between lead and a processing alternative.

An economic analysis will take into consideration all of the factors that affect the costs of making your gasoline: for example, optimum rates and yields, raw-material costs, product prices, operating manpower, maintenance and repair, utilities, depreciation, investment charges and reasonable "pay out."

TABLE 1. Estimated Pool Octanes and Premium — Regular Octane Numbers

		With 2.2 ml/gal TETRAETHYLLEAD	With 3.0 ml/gal TETRAETHYLLEAD
At the end of 1953	Pool	88.0	89.4
	Premium	92.9	94.3
	Regular	85.9	87.3
At the end of 1954	Pool	89.3	90.7
	Premium	94.2	95.6
	Regular	87.2	88.6
At the end of 1955	Pool	90.8	92.1
	Premium	95.7	97.0
	Regular	88.7	90.0

Octane improvement analyzed

From such an analysis you can determine the economics of octane improvement, which is the tool for obtaining the optimum sequence of processing steps and attendant use of tetraethyllead. Analyzing octane improvement costs calls for a thorough understanding of unit operating costs, particularly when incremental expenses are being considered.

There are several approaches for analyzing the costs of octane improvement at higher levels. At Ethyl we have found, through our studies of the economics of top octanes, that the key to cost analysis is a value called *incremental cost*. Simply expressed, this is the rate at which costs increase as you raise the octane number. It can be expressed conven-

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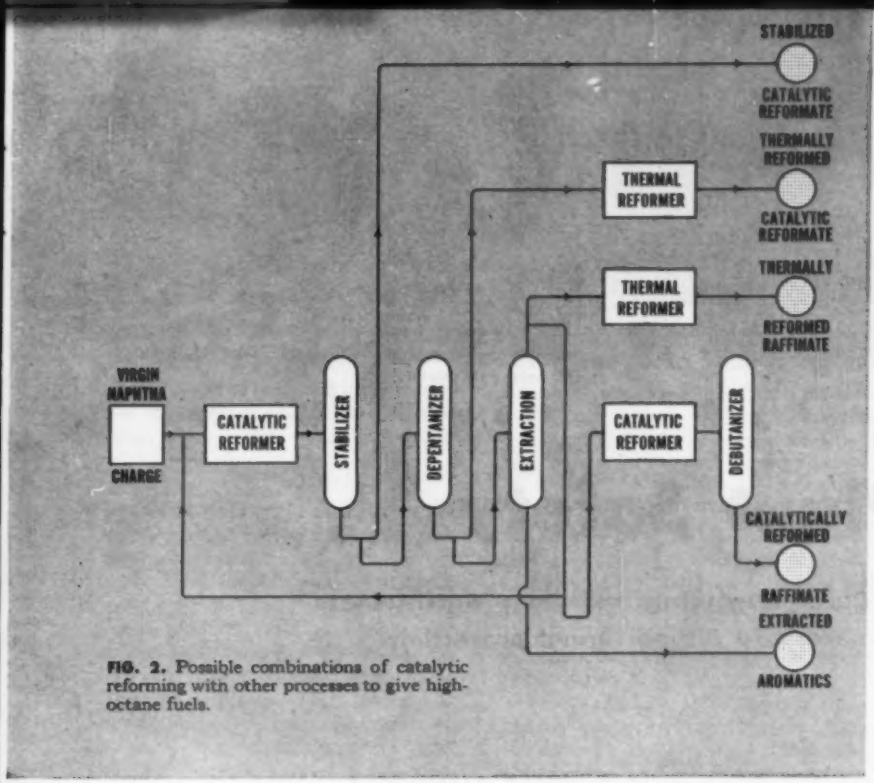

FIG. 2. Possible combinations of catalytic reforming with other processes to give high-octane fuels.

iently in cents per Research octane number per barrel. (¢/RONB).

Once you determine incremental costs, the next step is to make sure you are employing the best possible process at each point. By plotting the cost curves on a chart, you will see that up to a point the cheapest way to improve gasoline is with lead. Then lead becomes closely competitive with mild reforming methods.

After you reach an incremental cost of about 5¢/RONB, it again is definitely cheaper to add tetraethyllead. And finally when the full 3 cc of lead is used, you must return to reforming—this time at greater severity.

Today there's a greater trend toward using lead in higher concentrations for, as one industry spokesman put it, "tetraethyllead has decreased steadily in price while the costs of refinery construction have continued to rise rather sharply."

With constantly increasing gasoline-quality demands facing the refiner, it has become increasingly important to define the optimum route to high-octane fuels. Lead addition now costs an average of 4 to 5 cents per Research octane number per barrel, and this is directly competitive with the cost of mild reforming operations for octane improvement. As product octane levels increase, refiners may have the choice of using maximum tetraethyllead—3 ml/gal—or going to more expensive reforming operations—more severe single pass reforming or extraction followed by raffinate reforming. Here—even though lead susceptibility decreases somewhat in aromatic reformates—the cost of octane improvement by lead becomes increasingly more attractive as compared with various processing alternatives. Where extremely high octane levels are required, a refiner has little choice but to use the more economic tetraethyllead to the maximum and then to vary his processing alternatives to give the desired product quality if he wants to hold his manufacturing costs to a minimum.

KNOW THIS EQUATION?

$$¢/RONB = \frac{(Y-100-F)(Pg-9.4T) + Pb(F+G) + Pf100H - 100E}{100\,RONp - 100\,RONn - 10F + Y(RONr - RONp)}$$

You should if you are making an economic analysis. Write for a copy of a recent 50-page report giving a definition of terms of this equation and other information on new processing alternatives and on the economics of top octanes. Address your request to Department **No. 22,** Ethyl Corporation, 100 Park Avenue, New York, New York. No charge.

HOW Ethyl Research can help you

Our Refinery Technology staff, backed up by the extensive facilities of the Ethyl Laboratories, will be glad to share their experience with your economics people when you conduct a cost analysis of your top octanes.

We will work with you, or if you prefer, we are even equipped to do a complete cost analysis for you.

We can help you answer these and other questions: When should you use "Ethyl" antiknock compound in preference to increasing the catalytic reformer charge rate? How does increased severity of reforming affect your costs? When should you carry your tetraethyllead content to the maximum allowable—and under what circumstances?

Your Ethyl Representative will be happy to arrange an appointment for you with one of our Refinery technologists.

ETHYL CORPORATION
Research Laboratories

1600 W. Eight Mile Road, Ferndale 20, Mich.
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ADVERTISEMENT

This neat building houses offices of the safety section and the first aid room.

Head Fire and Safety Inspector Elmer Saxon explains some safety equipment to Inspectors W. H. Berkley, left, and R. F. Hefley.

P 934.314.

Chemical Plant Safety

Careful training, incessant watchfulness necessary for personnel protection

Elmer Saxon
Safety Department Manager, Shell Chemical Co.

SHELL Chemical Corporation's plant on the Houston, Texas, ship channel is one of the largest petrochemical installations in the world, employing more than 1600 persons and manufacturing some 25 products from petroleum-derived raw materials.

As in all plants of this type, employees work in some proximity to pressures, chemicals, and equipment which, by their very nature, are potentially dangerous. From the first day the plant went into operation, therefore, safety has been one of the prime concerns.

As evidence, *the first place a new worker goes after filling out his employment papers* is to a meeting with a representative of the plant's safety section. Before he even sees where he is going to work he is given a complete orientation in general safety practices and procedures in effect throughout the plant, and issued safety hat, goggles, gloves, and a booklet outlining safety rules and regulations. And this is but the first step in a program of training in safety that will continue as long as the man is employed at the plant.

A modern first aid room and related facilities for administering emergency aid to the injured are maintained on the plant grounds. Registered nurses supervise these activities and are also responsible for keeping up-to-date reports of all injuries. A plant ambulance stands by on 24-hour call.

The plant's safety program is planned and coordinated by a highly trained staff under the direction of a head fire and safety inspector who reports to the manager of the personnel and industrial relations department.

EXCLUSIVE

Inspector W. H. Berkley of the plant's safety section, left, inspects a hand extinguisher of the dry chemical type, which is used in outdoor areas. A fire blanket is in its cabinet above the extinguisher. Center, well marked, lever-actuated safety showers are located in each process area. Right, a high-pressure, stationary monitor is checked for proper operation. Nozzles on these monitors have full 360-deg traverse. Housing in left foreground contains quick-acting hose reel.

This 750-gal fire truck and ambulance are on 24-hr call. Fire crews are thoroughly trained in the operation of all fire control apparatus. Inspector R. F. Hefley explains operation of some of the fire truck's controls.

Safety meetings are held in each craft or operating department. These meetings are planned by the safety staff and conducted by the supervisors. Here is a meeting of the carpenters.

Responsibilities of the safety section are: Accident prevention, fire prevention, and control.

Accident Prevention. Safety inspectors in this division have these general responsibilities: Inspection of maintenance and operating equipment for safe operating conditions; inspection of safety equipment; maintenance of safety supplies; reporting of accidents — cause, nature and corrective steps; planning and supervision of safety meetings.

Fire Prevention and Control. The duties of the safety inspectors are: Inspection and maintenance of fire extinguishers and related equipment; issuance of fire permits; training of fire control personnel.

But while this staff of experts plan the safety program, *it is actually carried out by the supervisor of each department.* It is the responsibility of these supervisors to see that each worker in his department is familiar with and observes both the plant-wide safety practices and any of a specialized nature that may pertain to the activities of that particular department.

The plant's general safety program is based on these points:

(1) Prompt reporting of injuries; (2) proper methods of chemical control and handling; (3) complete understanding of job assignments and safety practices to be followed in carrying them out. Specialized safety procedures are generally elaborations of these broad rules.

It is a widely accepted principle among safety experts, however, that the secret to any successful safety program is the *attitude that the worker himself takes toward safety*. He must first convince himself of the value of safe practices and get the safety habit through application and practice. This fundamental is the basis for what is considered the most important single phase of the entire plant program. Departmental safety meetings are conducted by the various operating and craft supervisors and are usually devoted to emphasizing one phase of the over-all program. Material for these meetings is planned in advance by the safety section, insuring orderly and complete coverage of the entire program.

Since fire is one of the most dreaded occurrences in any plant dealing with large quantities of volatile materials, perhaps a bit more should be said about Shell Chemical's extensive fire prevention and control system. Here again, emphasis is placed upon training and planning to prevent fire.

Before starting any operation that requires welding, cutting, grinding, or open fire, a workman must first obtain a fire permit from the safety section. Before this permit is issued, a fire and safety inspector must inspect the equipment to be used and the area where the job is to be done. He checks to be certain that the area is gas-free, that sewers are sealed and that lines involved are blinded or disconnected from their vessels, and that the vessels are purged of gaseous or chemical contaminants.

In the rare instance that a fire should occur in spite of all precautions, a highly organized fire control plan goes into action. Phones in every operating area connect directly with the central fire station, where the plant maintains a fire truck and other modern mobile equipment. The entire plant is equipped with a high pressure grid fire water system with outlet hydrants at 200-ft intervals. In each operating area are turret-type fire water monitors and quick-acting hose reels with adjustable fog nozzles. CO_2 hand extinguishers are kept in all laboratories and control rooms where combustible materials are used or stored, and also in offices and electrical switch rooms. Dry chemical hand extinguishers are used in all outside and process areas.

Fire crews including an electrician and ambulance driver are on call 24 hours a day. These crews are composed of operating and craft employees from each shift and are highly trained in the operation of all fire equipment. Members of these crews are trained by the safety staff and department managers. In addition, personnel in each process area are trained in the use of all stationary equipment in their respective areas. In event of fire, the department manager of the area involved acts as fire chief and directs control activities.

* * *

Safety Inspectors H. J. Ward and W. L. Whittington discuss the use of one of the safety devices used for protection of personnel.

Trained nurses at work in the plant first aid station. Left to right, Mrs. Worthington, Mrs. Karney.

A non-silicone type grease will lubricate ball bearings satisfactorily over a 515 F temperature range

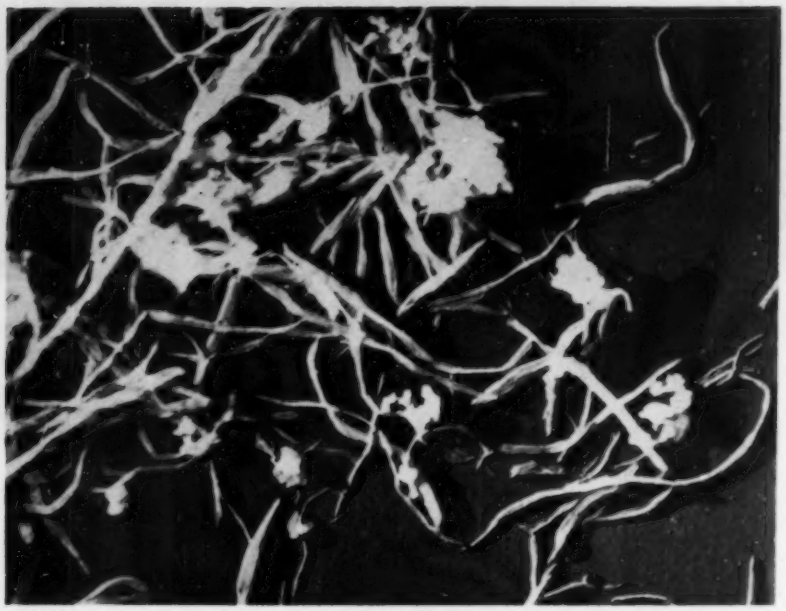

FIG. 1. **Electron micrograph** of the mixed —soap and non-soap—thickener in the grease.

NEW GREASE FOR HIGH TEMPERATURE Ultra High Speed Operation

J. Perry Dilworth and James R. Roach
Beacon Laboratories, The Texas Company
Beacon, New York

PURPOSE of this paper is to discuss the performance of a new, mixed soap-solid thickened synthetic oil grease. This new product contains a non-silicone type oil and is the result of continuing research work directed towards the development of wide-temperature range greases satisfactory for high-speed bearing lubrication. This grease will satisfactorily lubricate ball bearings over the approximate temperature range of —65 to 450 F.

Fig. 1 is an electron micrograph showing the mixed thickener structure of this type product. This combination of soap and non-soap thickener makes an important contribution to the excellent performance characteristics of this grease.

Properties of the synthetic oils used in greases for high-temperature, high-speed applications differ considerably from those used in low-temperature greases. This is illustrated in Table I. It will be noted here that the synthetic oil used for high-temperature grease has somewhat higher flash and fire points and considerably higher viscosities at —65, —40 and 210 F than does the synthetic oil used for MIL-G-3278 low-temperature grease. Evaporation characteristics of the synthetic oil used for high-temperature grease are also better than those used for low-temperature greases.

Typical physical and chemical properties for the grease under discussion are shown in Table 2. It has been made in NLGI grades 0, 1 and 2 and gives satisfactory high-temperature and high-speed bearing performance in all three grades. The selected range appears to be satisfactory for most applications. On the basis of 100,000-stroke penetration tests, it is not particularly shear-stable. The dropping point of 381 F shown here is typical when run by the ASTM method. This may seem strange for a high-temperature grease, but we have found that this is not an actual melting point but a bleed point. In tests conducted using an aluminum block, we have found that this grease does not actually melt until a considerably higher temperature is reached. This grease does not corrode copper. It is resistant to water washing and prevents rusting of steel

TABLE 1. Properties of synthetic oils for low and high-temperature greases.

MIL-G-	3278[a]	
Use	Low temp.	High temp. High speed
Sp. gr. 60/60 F	0.917	0.955
Flash, COC, F	435	465
Fire, COC, F	485	535
Kin. vis. at —65 F cs	15,000	150,000[b]
—40 F cs	1500	27,000
210 F cs	3.38	9.2
Vis. index	150	140
Pour point, F	Below —65	—65
Evaporation 4 hr at 400 F	5.9	2.7

a Grease; aircraft and instrument (for low and high temperatures)
b Extrapolated

TABLE 2. Typical physical and chemical properties.

ASTM penetration	
Worked, 60 strokes	335
Dropping point, F	381
Copper corrosion, MIL-L-3545[a]	
24 hr at 212 F	Pass
Dynamic water resistance	
Grease loss, per cent	2.5
Salt spray test, MIL-G-15793[b]	
Rust in 50 hr, per cent	None
Evaporation	
100 hr at 300 F, per cent	3.4
Oil bleeding	
30 hr at 300 F, per cent	15
ASTM bomb oxidation	
Pressure drop in 50 hr at 300 F, lb	27

a Lubricating grease; high temperature
b Grease, instrument

in the presence of salt water. Evaporation at 300 F is low, and bleeding at 300 F is considered reasonable. In the ASTM Bomb Oxidation Test at 300 F, this product exhibits some pressure drop. None of these static tests are considered particularly significant when it comes to predicting or measuring actual grease performance.

The low-temperature properties of this grease, designated in subsequent tables as Grease A, are illustrated in Table 3.

Some tests for present MIL-G-3278[1] and MIL-L-3545[2] specification greases are also shown for comparison. The apparent viscosity for this product at —40 F is somewhat higher than for MIL-G-3278-type greases at —65 F. This grease has, however, much better low-temperature properties than MIL-L-3545 grease as shown by starting and running torques. Here, Grease A at —40 F shows approximately the same values as MIL-L-3545 greases do at O F. Low-temperature torque values again show that Grease A is considerably better than MIL-L-3545 greases but not as good as MIL-G-3278-type products. It is anticipated that Grease A will, however, operate at —65 F in a number of aircraft accessories where torque requirements are not too severe. The ability of a grease to lubricate these accessories at a given low temperature depends on the power available. This was clearly illustrated in a presentation on "Low-Temperature Operation of Aircraft Accessories" made at the ASLE meeting in April this year.[3]

High-temperature performance properties of this product are shown in Table 4. The values shown here for tests at 10,000 rpm in No. 204 bearings are averages of a number of tests for each type of product. MIL-G-3278-type greases have an upper useful temperature limit of about 300 F, for short periods of time. MIL-L-3545-specification greases will operate considerably longer at 300 F but for only short periods at 350 F. On the other hand, Grease A will operate for long periods of time at 350 F, for reasonable periods of time at 400 F and for short periods even at 450 F. Slower speed tests using larger bearings, such as in the Navy Silicone Motor Generator Test set, indicate that Grease A is much better than either of the other type products. This new grease ran for over 5000 hr at 300 F in this test. This far exceeds the 2000 hr required by MIL-L-15719A[4].

We know that some greases prepared with silicone-type oils will operate for longer periods of time than Grease A at high temperatures when speeds are 10,000 rpm and under. Most of these products will not satisfactorily lubricate ball bearings when the speeds are above 10,000 rpm when using No. 204 ball bearings. The performance of grease A in ultra-high speed ball bearings is shown in Table 5.

At 35,000 rpm using 204 bearings, Grease A and the MIL-L-3545-type grease both pass a 64-hr endurance test when using 80 lb of thrust load to generate approximately 200 F bearing temperatures. MIL-G-3278 greases will not run the full time under these conditions. Greases prepared with various silicone oils using the same thickener as used in Grease A will consistently run less than 2 hr time to bearing failure under these same conditions. In another type of test using a lighter load and external heat to develop 300 F outer bearing race temperatures, the new product will operate better than 300 hr at 35,000 rpm. In this case, the MIL-L-3545-type grease does not operate nearly so well and MIL-G-3278-type greases are unsatisfactory. In other words, when we bring speed and temperature together in the same type of test, the new product out-performs the others by a considerable margin. In preliminary tests in another type unit, using Series 100 bearings at 65,000 rpm and 250 F, we have obtained better than 500 hr of operation with Grease A. It is now being tested at 50,000 rpm in 204 bearings under light load. These data show that the new product is capable not only of lubricating at high temperatures but is also capable of lubricating ball bearings in the ultra-high speed range. This is important! Excessive temperatures in aircraft accessory equipment can sometimes be eliminated by changes in design, but maximum power output usually requires full speed.

Load-carrying capacity and wear characteristics are compared in Table 6. Grease A has an average Mean Hertz Load of 40 in comparison with

TABLE 3. Low-temperature properties.

	Grease A	MIL-G-3278	MIL-L-3545
Apparent viscosity at, F.	—40	—65	—
Poises at 20 sec—1	9000	6100	—
Starting and running torques, g-cm			
Temperature, F	—40	—65	0
Start	700	389	800
Run	200	85	225
Low temperature torque (2000 g-cm.)			
Temperature to reach,			
10 sec/ rev, F	—50	—80	0
+120 sec/rev, F	—80	—100	—20

TABLE 4. High-temperature performance.

	Grease A	MIL-L-3545	MIL-G-3278
High-temp. performance test, 10,000 rpm, 204 brg.			
Avg. hr to failure at			
250 F	—	2500+	2000
300 F	—	950	300
350 F	1050	151	—
400 F	290	—	—
450 F	65	—	—
Navy silicone motor generator test, MIL-L-15719A, 1750 rpm, 310 brg.			
Hours to failure at			
300 F	5386	900	150

TABLE 5. High-speed performance.

	Grease A	MIL-L-3545	MIL-G-3278
High-speed spindle tests			
35,000 rpm, 204 brg.			
Avg. hr to failure at			
200 F 80-lb thrust load	64+	64+	46
300 F, 20-lb thrust load	304	63	3

TABLE 6. Load-carrying and wear characteristics.

	Grease A	MIL-G-3278
Mean hertz load, kg	40	18
Navy gear wear test steel on brass		
mg wear/1000 cycles		
5-lb load	1.4	1.4
10-lb load	2.4	2.4
Steel on steel		
Mg wear/10,000 cycles		
7-lb load	3.7	4.0
Four ball wear test		
30 min at 200 F		
Scar dia., mm		
10-kg load	0.521	0.584
28-kg load	0.696	0.737
40-kg load	0.838	1.730

TABLE 7. Tests in full-scale aircraft accessory equipment.

Equipment type	Fuel pump	Fuel pump
Bearing size	104	104
Speed, rpm	25,000	25,000 to 55,000 in 2½-min cycles
Temperature, F	275	315
Operating time	50 hr	350 cycles
Performance		
MIL-G-3278 grease	High leakage	Bearings fail
Grease A	No leakage	Bearings and grease O.K.

TABLE 8. Tests in full-scale aircraft accessory equipment.

Bearing size	203
Speed, rpm	25,800
Temperature, F	230 F
Operating time	50 hr
Performance	
MIL-G-3278 grease	High leakage
Grease A	No leakage

[1]Grease, Aircraft and Instrument (for low and high temperatures).
[2]Lubricating grease, high temperatures.
[3]"Low Temperature Operations of Aircraft Accessories," E. A. Baniak and R. S. Barnett, Beacon Laboratories, The Texas Company, presented at the national meeting of ASLE, Chicago, Illinois, April 13-15, 1955.
[4]Lubricating grease (high temperature, electric motor, ball and roller bearings).

the 18 to 20 usually obtained on MIL-G-3278-type greases. In the Navy Gear Wear Test, using both steel on brass and steel on steel, the wear characteristics of the new product are approximately equivalent to the MIL-G-3278-type grease. In the Four Ball Wear Test, Grease A shows slightly better wear-prevention characteristics than does the other product. Thus, it would appear than in Grease A we have the good combination of high load-carrying capacity, coupled with low wear.

The tests that have been discussed up to now are, for the most part, laboratory bench-type tests. The proof of the usefulness of any product, however, awaits testing in full-scale equipment of the type that it is intended to lubricate. Grease A has been tested in full-scale aircraft accessory equipment by the manufacturer. Representative tests are shown in Table 7. Here two different types of fuel pumps containing 104 bearings were used. In one case, the rpm is constant at 25,000 and the temperature at 275 F; in the other case, the operation is cyclic from 25,000 to 55,000 rpm at a temperature of 315 F. In the first unit, practically all the MIL-G-3278-type grease is gone at the end of 50 hr of operation. Grease A when tested in the same equipment exhibits practically no leakage in 50 hr and lubrication is satisfactory. In the other type of equipment, when lubricated with MIL-G-3278 grease, the bearings would either fail before reaching the 350 cycles or failure would be imminent in the event that 350 cycles were reached. The same unit lubricated with Grease A and tested under identical conditions has operated satisfactorily through 350 cycles with apparently no deterioration either of the bearings or the grease.

A further test in full-scale aircraft accessory equipment is summarized in Table 8. In such a unit containing number 203 bearings, operating at 25,800 rpm and 230 F, almost no grease is left on the bearings at the end of 50 hr when lubricated with MIL-G-3278-type grease. With Grease A, however, practically no leakage occurs and the bearings and the grease remain in good condition.

Thus, it appears from these tests in full-scale aircraft accessory equipment that this grease is capable of lubricating ball bearings over a wide range of temperatures and speeds. There is no government specification at the present time covering this new type of grease. It appears, however, that this product will have an important place in aircraft accessory lubrication. * * *

This paper was presented before National Lubricating Grease Institute, Chicago, October 31-November 2, 1955.

The Author

J. Perry Dilworth

James R. Roach

J. Perry Dilworth was born in Arkansas City, Kansas, but considers Winfield, Kansas, his home town. He received his early education there and also attended the local Southwestern College for one year. He received his B.S. in industrial chemistry from Kansas State College in 1939. Dilworth joined The Texas Company's Beacon Laboratories, Beacon, New York, in 1939, as a chemist in the analytical and testing department. He is presently serving as acting supervisor of the grease research department.

James R. Roach is a chemist in the grease research department of the Beacon Laboratories. Roach was born in Malta, Montana but grew up in Chester, Montana. He holds a B.S. in chemistry from Montana State College and has been a member of Beacon Laboratories since shortly after his graduation in 1947.

AVERAGE RESEARCH OCTANE NUMBERS—Ethyl Corporation Survey

	Premium gasoline		Regular gasoline	
	Dec. 1955	Dec. 1954	Dec. 1955	Dec. 1954
Albuquerque, New Mexico	96.1	91.8	86.6	82.8
Amarillo, Texas	96.2	91.4	87.2	83.8
Atlanta, Georgia	96.8	95.2	89.0	87.1
Bakersfield, California	95.8	93.2	86.1	83.2
Baltimore, Maryland	96.8	95.0	90.7	89.6
Billings, Montana	94.1	92.6	86.7	85.3
Birmingham, Alabama	97.3	94.6	89.4	87.0
Boston, Massachusetts	97.1	95.1	90.9	90.1
Buffalo, New York	96.6	94.6	90.6	88.9
Casper, Wyoming	92.7	91.0	84.8	83.7
Central Michigan	95.2	94.2	88.9	87.0
Charlotte, North Carolina	97.2	94.4	88.8	87.0
Chicago, Illinois	95.1	92.4	88.5	85.1
Cincinnati, Ohio	95.6	93.8	90.4	87.8
Cleveland, Ohio	95.5	94.2	90.3	89.0
Corpus Christi, Texas	96.9	93.7	88.4	86.4
Dallas-Fort Worth, Texas	96.8	95.5	88.0	87.3
Denver, Colorado	91.4	91.0	83.8	83.4
Detroit, Michigan	95.2	94.2	89.8	88.4
El Paso, Texas	95.7	92.9	86.5	82.6
Fargo, North Dakota	94.4	92.0	86.2	84.7
Hartford, Connecticut	97.1	94.6	90.9	90.2
Houston, Texas	97.1	95.7	88.2	87.6
Indianapolis, Indiana	95.2	92.8	89.7	85.3
Jackson, Mississippi	97.1	94.8	89.0	87.1
Jacksonville, Florida	96.6	94.8	90.0	89.5
Kansas City, Missouri	94.1	92.1	86.7	84.8
Little Rock, Arkansas	97.5	95.1	89.2	86.8
Los Angeles, California	95.8	94.5	85.8	84.2
Louisville, Kentucky	96.2	94.4	88.8	86.6
Memphis, Tennessee	97.0	95.2	89.1	87.2
Metropolitan New York-New Jersey	97.0	95.1	91.0	89.9
Milwaukee, Wisconsin	94.8	94.0	88.8	85.1
Minneapolis-St. Paul, Minn.	94.5	92.0	86.6	84.6
New Orleans, Louisiana	96.4	95.5	88.8	87.3
Northwest Pennsylvania	94.7	93.8	90.4	88.2
Oklahoma City, Oklahoma	94.3	92.3	86.6	84.9
Omaha, Nebraska	94.0	91.6	86.2	84.7
Philadelphia, Pennsylvania	96.9	94.9	90.8	90.4
Phoenix, Arizona	96.2	93.5	86.8	84.0
Pittsburgh, Pennsylvania	97.1	94.9	91.6	90.1
Portland, Oregon	96.2	94.1	87.1	84.5
Richmond, Virginia	96.7	94.7	90.6	89.5
Salt Lake City, Utah	93.1	91.0	82.5	82.2
San Antonio, Texas	96.1	96.1	88.2	87.5
San Francisco, California	96.3	94.6	86.9	84.8
Seattle, Washington	95.6	94.1	86.2	85.0
Shreveport, Louisiana	96.7	95.1	88.2	87.0
Spokane, Washington	95.4	93.3	86.6	84.9
St. Louis, Missouri	94.3	92.1	87.1	84.8
Toledo, Ohio	94.6	93.9	89.8	88.6
Tulsa, Oklahoma	94.2	92.7	86.3	84.9
Wichita, Kansas	94.3	92.3	86.2	84.9

TECHNOLOGY

Refining of Lubricating Oils

Section I; Conventional Processing

Acid and clay treatments and deasphalting are a few of the methods for refining lubricating fractions.

V. A. Kalichevsky
Consulting chemical engineer.

CHEMICAL composition of heavy petroleum fractions used in the manufacture of lubricating oils is complex. They consist of a vast number of hydrocarbons having an intricate structure that defies all the attempts of isolating the individual compounds. The nature and the relative quantities of these materials can be determined only approximately. The results of such analyses, however, are important for visualizing the refinery operations.

Composition of Lubricating Oils

The lubricating oil fractions contain some or all of the following components: Wax, asphalt, low-viscosity index hydrocarbons and high-viscosity index hydrocarbons. They are isolated by treating the oil with solvents. The general characteristics of these components are as follows:

Wax is a well known substance that is solid at room temperature. Solutions of wax in oil solidify on cooling. This interferes with the free flow of oil in service. The larger the percentage of wax, the higher the congealing temperature or the pour point of the oil.

Asphalt is also a common material. It does not distill but cracks on heating to high temperatures and forms carbon. Oils containing asphalt are unstable and carbonize the engine. They have a high carbon residue and coke number. These tests are made by heating the oils to high temperatures and weighing the solid residue left in the vessel.

The low-viscosity index constituents are liquid. As the name indicates, their viscosity changes considerably with temperature. Many of them are unstable in service. These undesirable characteristics require their removal from high-grade products.

The high-viscosity index constituents are the valuable lubricating oil components. Their viscosity changes comparatively little with temperature, and they are stable in service. The objective of lubricating oil refining is their recovery from the crude oil.

This does not mean that wax, asphalt, low-viscosity index and high-viscosity index constituents are distinct components of the unrefined oils. The oil consists of an infinite number of substances of varying characteristics. Their properties change imperceptibly from oil to wax and from oil to asphalt. No sharp demarcation line can be drawn between them. For instance, wax is known as a solid substance that separates from the oil on cooling. Solids change into liquids when they melt, and if a solid melts below the room temperature, it is called a liquid. Definition of the room temperature depends on the climate. Wax of any melting point can be obtained from the crude oil, and a decision must be made when it stops being wax and becomes oil. If a 130 F melting point for wax is agreed upon, the wax content of the oil will be lower than if 120 F melting point is accepted as the dividing line. At very low temperatures, all the oil solidifies and may be classified as wax of a very low melting point. At a temperature above the melting point of any hydrocarbon present in an oil, all the wax may be regarded as oil.

The same uncertainties exist in drawing a line between oil and asphalt and the rest of the oil constituents. Hydrocarbons forming wax of progressively lower melting points change gradually into the high-viscosity index constituents. These constitutents change also gradually into the low-viscosity index constituents, which cannot be separated sharply from asphalt.

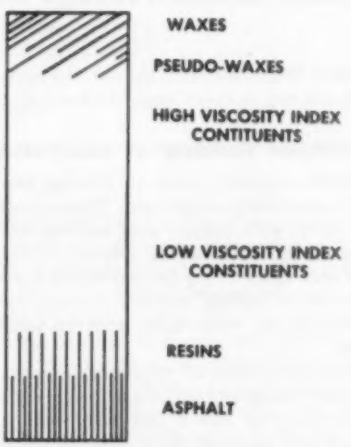

FIG. 1. Main constituents of the heavy fractions of crude petroleum.

The two extreme types of substances present in the unrefined portion of the crude oil are wax and asphalt as shown in Fig. 1. Their presence in the finished products is

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objectionable, but that of hydrocarbons intermediate between oil and wax, that is pseudo-waxes, or of hydrocarbons intermediate between oil and asphalt, that is resins, may be desirable. In developing an oil to be used for some specific purpose, the boundaries between the desirable and undesirable crude oil constituents must be determined experimentally for obtaining a product of best quality. Over-refining can be as harmful as under-refining.

The crude oil source is important in the lubricating oil manufacture. Waxes of the same melting point but separated from different crude oils may not have their other properties alike. Oils of the same viscosity index may not be equally stable in service. Characteristics of asphalts also vary within wide limits. For instance, lubricating oils prepared from the low-viscosity index Coastal crude oils are much more stable than the fractions of the same viscosity index isolated from the high-viscosity index Pennsylvania crude oils. Approximate distribution of the various oil constituents in typical crude oils is shown in Fig. 2. This does

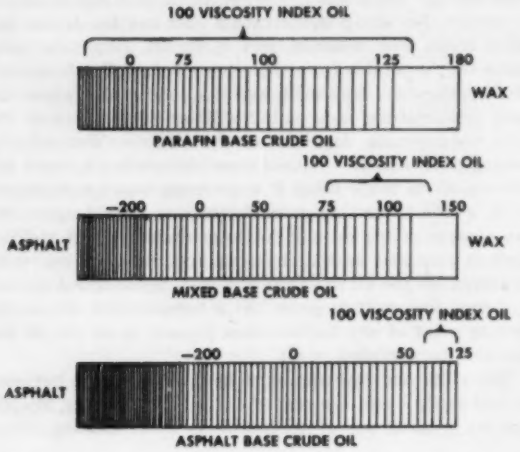


FIG. 2. Approximate composition of crude oils of different bases.

not imply that the apparently similar fractions present in these crude oils are in every respect identical.

Conventional Refining of Lubricating Oils

The methods originally used for refining lubricating oils are not yet completely abandoned. They consist in agitating the raw stock with sulfuric acid, settling the sludge and neutralizing the oil with caustic solution or clay. The oils neutralized with caustic may be also finished with clay. Sulfuric acid removes asphalt and low-viscosity index constituents but does it less thoroughly than the solvents now in common use.

Acid treatment is done at temperatures sufficiently high to permit good mixing and settling of the acid sludge. These temperatures may be 125 F and higher for very viscous oils. Pennsylvania residual stock must be treated at about 140 F. Best results are obtained at the lowest temperatures at which the oil can be satisfactorily handled in the agitators. High treating temperatures "burn" the oil. Such oils have a dull brownish color that is difficult to improve by additional refining. Low temperatures produce unsatisfactory oils because the separation of sludge is incomplete.

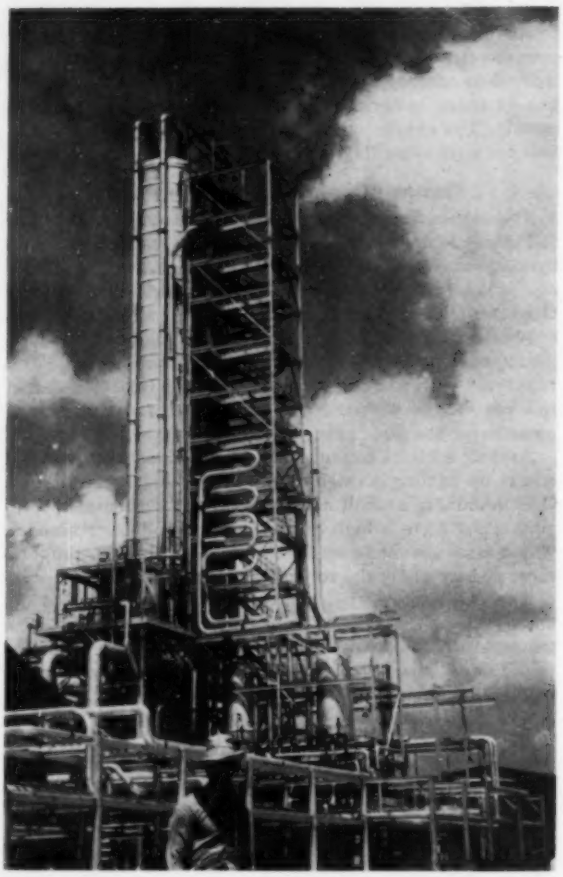
A typical acid treating procedure is as follows. The oil heated to the proper temperature is pumped into an acid agitator. This is a tank with a conical bottom having a valve for withdrawing the sludge. The tank may be equipped with coils for heating or cooling the oil with steam and water. A line carrying compressed air extends to the bottom of the tank for agitating the oil-acid mixture. Most of the tanks are covered with roofs as a protection against rain. Acid is introduced at the top of the tank through a pipe to which a spray may be attached. Many of these acid agitators hold as much as 1000 or 1500 bbl of oil.

Air agitation is started before the acid is pumped in to insure good mixing. Acid is added gradually for the same reason. Severity of agitation is important. The oil and the acid must be mixed thoroughly, but the sludge particles should not be broken down and dispersed through the oil, which makes settling difficult.

Acid is added in quantities not exceeding 20 or 30 lb per barrel of oil. If a large volume of acid is added at once, some of the oil will be attacked by a disproportionately large quantity of the acid before it is dispersed. As a result, the oil will be overtreated and overheated locally and become "burned." The amount of heat generated on mixing the oil with acid is considerable, and this must be taken into account in adjusting the treating temperature. The temperature at the end and not at the beginning of the treat is the one that counts.

The 98 per cent sulfuric acid is commonly employed. It is important that air used for agitation is dry. Acid easily absorbs moisture from the air and loses its efficiency.

Agitation is continued for 20-30 min until the acid "bites" into the oil, that is, until distinct particles of sludge are formed. Then agitation is reduced, and water may be



A. A high vacuum unit in a Venezuelan refinery, for distilling heavy fractions.

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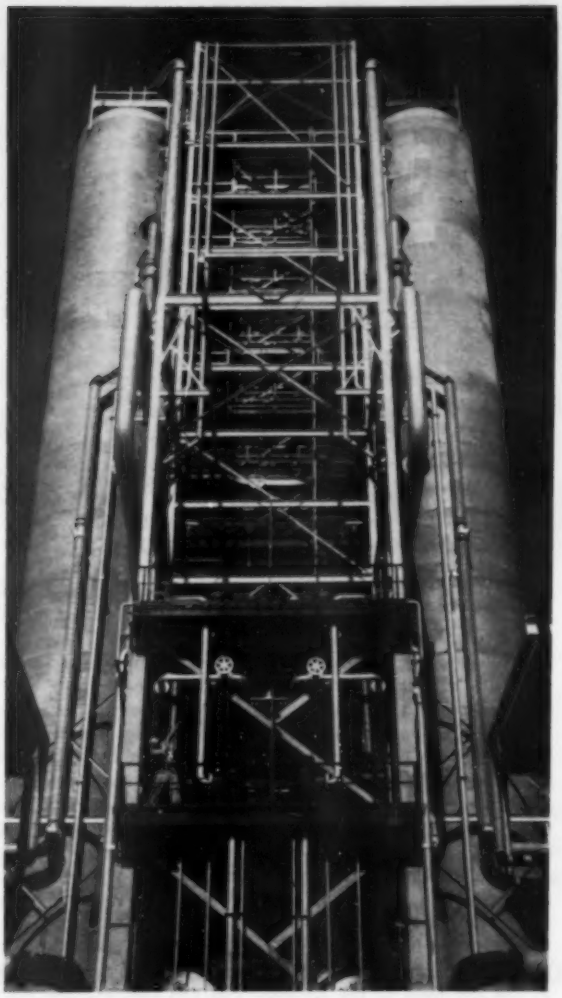

B. This double vacuum unit in a Gulf Coast refinery takes "the heart out" of heavy crude fractions to make highly improved lubricating oils.

added to assist in the coagulation of the sludge. Water decomposes the sludge, and the quantity of water added must be as small as possible, not over 0.5 per cent by volume on the oil charge. As always, there are exceptions. Heavy residual oils from Mid-Continent crudes may require up to 2 per cent of water. The higher the viscosity of the oil, the larger is the volume of water needed for collecting the sludge particles. When the sludge particles reach the size of a pinhead, agitation is discontinued and the sludge allowed to settle.

Sludge must be removed as soon as it is formed. The first portion of the sludge should be withdrawn 10-15 min after agitation is stopped. Most of the sludge will settle in 1-2 hr. The oil is then allowed to stand for 8-12 additional hours to settle the rest of the sludge. If acid is added in portions, the settling time between the additions of acid is reduced to ½-1 hr and no water is added except after the last quantity of acid is introduced.

A small quantity of sludge is left in the oil even after the separation appears complete. It is removed by blowing the oil with air for several hours at 150 F or a higher temperature. The oil is allowed again to stand for the sludge particles to settle and then transferred into another agitator for neutralization with caustic.

Temperature at which the oil is neutralized can be considerably higher than that used in the acid treatment because oil is stable in the presence of caustic. Emulsions are often formed, particularly when the neutralized oil is washed with water. To avoid their formation, temperatures as high as 150-180 F are common for this operation. For the same reason, the strength of the sodium hydroxide solution may be as low as 2 per cent (2 B5). Importance of the emulsion problem varies with the nature of the stock and the success of the acid treatment, particularly in obtaining complete separation of the sludge. Sometimes oil is added to the caustic solution instead of adding the solution to the oil. The caustic solution may be injected into the oil while the mixture is heated by circulating it through heat exchangers.

In washing the neutralized oil with water, formation of emulsions may be avoided by using a water spray without agitating the oil, or by bubbling the oil through a layer of water. This removes most of the emulsion-forming substances. Then the water is used in regular manner, that is, the oil-water mixture is blown with the air and settled. After the water is drawn off, the oil is blown with air to remove the traces of moisture.

Clay Treatment

Oils are treated with clay for improving their color and color stability. Clay treatment may also improve other properties of an oil, such as the tendency to form emulsions or the resistance to the passage of electric current. The two best known methods of applying clay to the oil are the Clay Contact Process and the Clay Percolation Process.

In the contact process shown in Fig. 3, the oil is mixed with a finely divided clay. The mixture is heated by passing it through a furnace and filtered. Clay acts as a neutralizing agent and is often applied to an acid-treated oil without

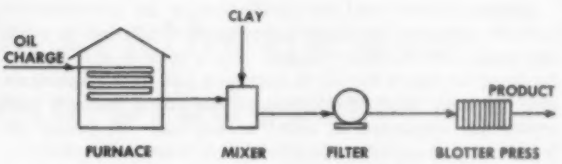

FIG. 3. Clay contact process for refining lubricants.

neutralizing it with caustic. The decolorizing efficiency of the clay is even considerably improved by the presence of acid, which is absorbed by the clay. The temperature to which the oil-clay mixture is heated depends on the nature of the stock. The decolorizing properties of most clays improve with the increase in temperature and to a smaller extent with the increase in contact time. High-viscosity stocks are treated with clay at higher temperatures than the low-viscosity stocks. Temperatures above 700 F, which are within the oil cracking range, may be employed.

Clays used in the contact process have a high moisture content. Moisture protects the clay from deterioration in storage. When moisture is expelled on heating, it forms a film of steam on the oil surface and prevents oxidation with air. Clay-water slurries were used in the past to facilitate handling problems at the refinery. Such slurries can be pumped around the plant, but heat required for evaporating a large excess of water makes the process expensive. Contact clays are not recovered but discarded after use.

Oils neutralized with caustic are often percolated through

coarse clay. Some oils, like those from Pennsylvania, are not treated with acid but only with clay. They may be pretreated with solvents.

Heavy oils are percolated at temperatures, sometimes as high as 200 F. They can also be percolated at room temperatures if they are diluted with naphtha to reduce their viscosity. Light oils are percolated at room temperatures without dilution. In distilling off the naphtha, low temperatures must be used for protecting the oil color.

Percolators, or filters, have a cylindrical shape and a cone bottom. They may hold as much as 60 tons of clay, but the 30-ton filters are more common. The oil flows downwards. Some plants force the oil upward through the clay bed in order to reduce channeling. This requires filters having walls of sufficient thickness to withstand the pressure. As percolation is done below the boiling temperature of water, the clay must be dry. The spent clay, often bauxite, is washed with naphtha and steamed before it is removed from the filters and regenerated by burning.

Oil can be treated with clay in the crude oil stills while distillation is in progress. The fine contact clay is mixed with the raw oil charge, and residuum containing the spent clay is withdrawn continuously from the bottom of the still and filtered. This modification of the contact method of clay treatment is known as the Filtrol Fractionation Process.

Modern Refining Methods

The new refining methods employ solvents. They separate asphalt, wax and low-viscosity index constituents from oil without changing them chemically like the sulfuric acid does. No sludge is produced. Separation between the various oil components is much sharper than that obtained with sulfuric acid. Sulfuric acid is still useful, however, in refining oils requiring a light treatment or in preparing special products, like medicinal and spray oils.

Deasphalting

Asphalt is removed by distillation or by precipitation with oil solvents, like liquid propane. If distillation is used, the crude residuum is charged into a special still that is designed to obtain the oil as overhead and leave asphalt as still bottoms. High distillation temperature, vacuum and steam are employed in order to vaporize the heavy oil fractions. A complete separation of oil from the asphalt by this method is difficult. Some of the high-boiling oil fractions remain in the asphalt. This reduces the yield and viscosity of the product.

In the Propane Process, the oil containing asphalt is diluted with propane. Propane has small-size molecules that mix with the molecules of the oil but not with the very heavy molecules of asphalt. These heavy molecules do not stay suspended in the oil-propane mixture but settle to the bottom and are removed as a precipitate. Liquid ethane or butane also precipitate asphalt, but the ethane molecules are very small and do not mix with all the oil molecules. Some of the oil is thus lost to the asphalt. Butane molecules are big and carry some of the asphalt into the oil. Propane gives the separation between the two oil components the refiner needs.

The early propane-extraction plants had stage contactors like those described in refining kerosine with liquid sulfur dioxide. In these extractions, it is important to separate all the oil from the asphalt. This is obtained by washing asphalt, leaving the exterior with fresh propane and employing this propane for diluting residuum entering the unit. In new plants, the same effect is obtained by using towers instead of separate stages.

In tower extractions shown in Fig. 4, residuum is fed at

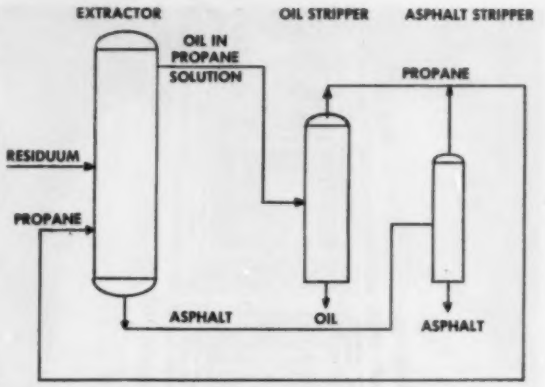

FIG. 4. Propane deasphalting process is employed widely to remove asphalt-type compounds.

the middle and propane near the bottom of the column. Asphalt is removed at the bottom and the oil-propane solution at the top. With this arrangement, asphalt in the upper section of the tower has time to settle instead of being carried out in suspension by the oil stream. In the lower section, asphalt is thoroughly washed with propane before it is discharged from the unit.

While asphalt settles within the tower, it is washed with a stream of propane moving upward and containing progressively smaller quantities of oil. In stage extractions, the number of times asphalt is extracted with propane is limited by the number of stages. In tower extractions, the existence of these stages is not apparent because they are ill-defined. A certain amount of channeling is unavoidable, which makes an estimate of tower efficiency in terms of stages only of approximate value. However, the number of washings each asphalt particle receives is large, and the overall effect is considerably greater than that observed by using a commercially reasonable number of stages.

Separation of asphalt and its removal from the bottom of the tower is improved by maintaining a lower temperature at the top than at the bottom. The top temperature controls rejection of asphalt and resins. The higher this temperature, the larger the quantity of asphalt and resins is rejected and the lower the viscosity, and the yield, of the recovered oil.

The temperatures at the top and at the bottom of the tower are usually 110 F and 160 F, respectively. Pressure is maintained at 450 psi to keep propane liquid. The propane to oil ratio varies from 5:1 to 12:1 by volume. Sharpness of separation is improved by increasing the quantity of propane in the mixture. Propane is separated from the oil and from the resins and asphalt by distillation. The quantity of propane in the mixture. The quantity of propane withdrawn with asphalt is small.

Propane separates the oil into fractions according to the size of their molecules. By varying the conditions of extraction, several fractions can be obtained and the charge stock can be separated into oil, resins and asphalt. Two towers are needed to accomplish this separation. In the primary tower, a temperature of 190 F or higher is maintained and the pressure is raised to 650 psi. Propane has a "critical temperature" of 204 F. At this temperature, propane behaves like a gas and the difference between liquid and gaseous propane disappears. Extractions can be made at temperatures above the critical if equipment can withstand the pressure. In the secondary tower, the extraction conditions are the same as in the deasphalting tower.

Section 2 of this article will appear in an early issue.

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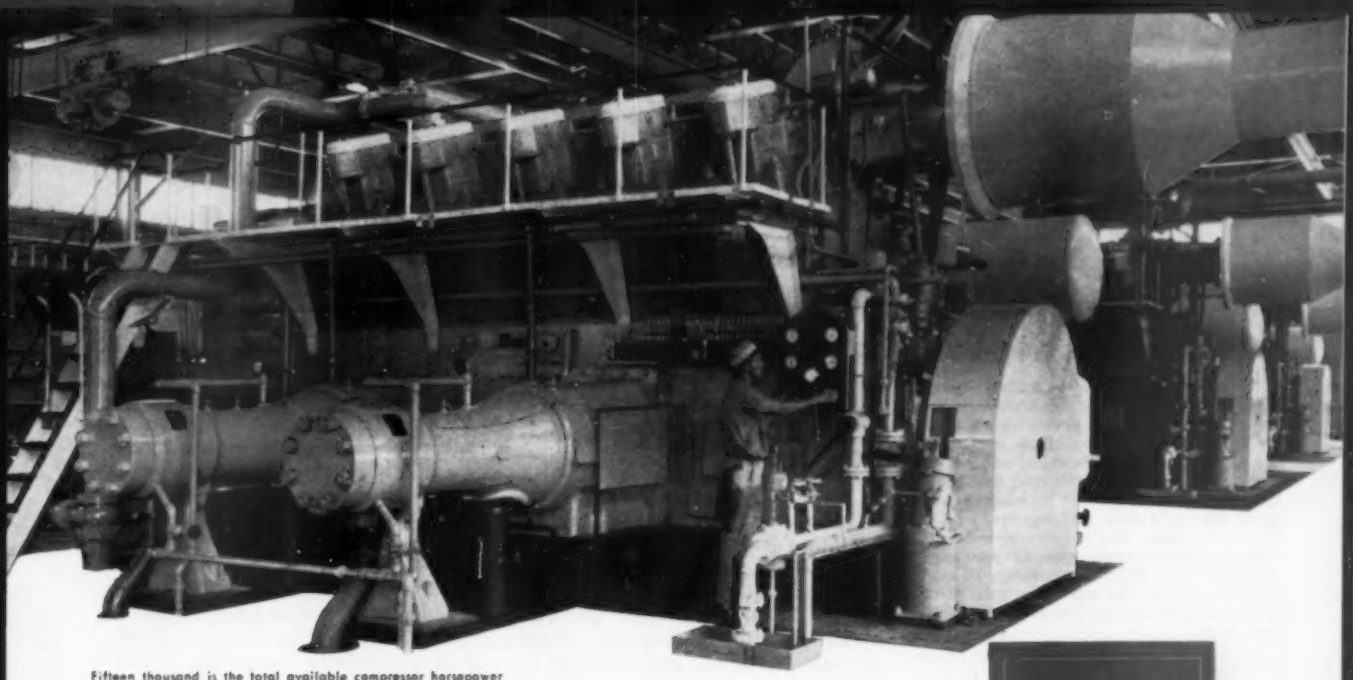

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TECHNICAL FORUM

Spent Alkylation Acid Recovery

Q In our refinery operation spent alkylation acid at approximately 90 per cent sulfuric acid concentration is used for treating lube stocks, then routed to our acid plant for hydrolysis, concentration, and fortification with new acid. Our schedules indicate that we may have more spent alky acid than will be required for lubeoils treating. Preliminary tests in direct (atmospheric) hydrolysis of spent alky acid indicate a high concentration of carbon remains in the aqueous phase after hydrolysis, which impairs the concentration step.

1. **Would pressure hydrolysis be more effective than atmospheric hydrolysis in producing a clean weak acid which could be concentrated without difficulty?**
2. **We would like to have a brief description of a pressure hydrolysis system, giving the essential components of the equipment and the operating procedure.**

E. K. B.

A Most refiners seem to have answered the question of how best to recover alkylation spent acid by saying "don't do it," and have disposed of it in other ways. It has been used for lube and for light oil treating, although some has been combined with other sludges to a tolerable extent in conventional acid recovery systems. Some refiners exchange it with chemical manufacturers for new acid and some neutralize it with ammonia and produce byproduct ammonium sulfate. So it might be called the problem child of the refining industry. Normally, spent alkylation acid contains about 2 to 5 per cent water and 5 to 15 per cent hydrocarbons, the latter in the form of sulfuric acid esters and hydro-polymerization products.[1] On dilution, these organic constituents largely remain in the acid and do not separate as a sludge in the manner characteristic of usual petroleum sludges. Hydrolysis by heating is usually incomplete and separates a cokey mass or a carbonaceous gel difficult to handle.

Small amounts can be combined with other sludge fed to a sludge coker operating at moderate temperature to produce SO_2, which is converted to sulfuric acid. Where sufficient amounts are available to justify the installation, a high-temperature, complete-decomposition process similar to that built by Chemical Construction Company for Consolidated Chemical Industries at Houston, Texas[2], may be the answer. In this process, the acid is burned with fuel and excess air at 1900 to 2200 F and the SO_2 converted to 98 per cent H_2SO_4.

Some of the difficulties encountered in alkylation sludge recovery can be surmised from the various methods used to solve the problem. Schmidl[3] heats the undiluted sludge to 280 to 325 F and obtains a gel that is broken up and leached to recover the acid. Wilde[4] describes diluting to 67 to 80 per cent H_2SO_4 and heating at 305 to 315 F from 20 minutes to 1 hr to separate a coke. The product is a black acid containing 1 per cent of carbonaceous matter. It can be fortified with SO_3. If not diluted below 80 per cent H_2SO_4, a rubbery mass is obtained on heating.

Extraction of the organic matter with white oil and other solvents, aided by sulfuric acid detergents is shown in patents of Standard Oil Development Company.[5] The sludge is first diluted to an acid concentration of 35 to 50 per cent. O'Dell[6] describes diluting to 30 to 40° Bé and heating with other refinery sludge at 140 to 212 F to separate organic matter. Slotterbeck[7] dilutes to 40 to 60 per cent H_2SO_4 and heats at 120 to 170 C for 2 to 5 hours, settles the flocculated carbon and concentrates in vacuum to 85 to 90 per cent. According to another patent,[8] acid of 98 to 99 per cent can be frozen out of the sludge and recovered by centrifuging.

In view of the above, the questions can be answered specifically as follows:

(1) Little advantage appears to result from use of pressure hydrolysis. The chief problem is handling the large amount of cokey matter that must be separated and there is no indication that the coke is any more granular when separated under pressure. Read[9] dilutes to 50 per cent and settles at 200 to 250 F, separates carbon, then partly concentrates under a pressure of 25 to 75 psi at 300 to 350 F. The use of pressure on the diluted acid speeds the hydrolysis but does not appear to make it more complete.

(2) Equipment for pressure hydrolysis must withstand severe attack by hot, dilute sulfuric and organic acids. Ceramic-lined vessels with Duriron or tantalum heating surfaces are most suitable. The well known Simonsen-Mantius evaporator is an example of this type of construction. Deposition of carbon on heating surfaces is a problem requiring careful consideration before installing any given type of equipment. This could be avoided by direct heating with superheated steam at 350 to 400 F and the desired pressure—for example, 50 psi.

J. L. Edgar[10] makes the statement that no method of removing separated carbon is entirely satisfactory. It can be filtered out on a Dorr-Oliver rotary filter and one refiner has succeeded in removing it by flotation in oil. One per cent carbon left in the acid causes the loss of 15 per cent H_2SO_4 when reconcentrated to 90 to 98 per cent, which explains why it is better to stop the reconcentration at about 80 per cent and fortify with SO_3.

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Vanderveer Voorhees.

Part of trend in crude oil production is indicated by the fact that 118,000 bbl of crude from Canada is delivered this last month by tanker to Tide Water Oil at Suisun Bay, California. Crude came from British Columbia from Alberta and is the first shipment from that area to the U. S. A.

Most advanced catalytic cracking unit in the world began operation at Shell's Anacortes, Washington, refinery. A fluid cat unit with a procedure to produce higher octane rating motor fuel than has been accomplished anywhere, it will process 50,000 bbl of crude per day.

Methods for testing the explosion properties of aviation gasoline, developed by the Inland Testing Laboratories will show how these all-important products can be "made safe for flying conditions", that laboratory announces, as result of its cooperation with Wright Air Development Center.

P 739.3

MECHANICAL ENGINEERING

Seals and Sealing Systems For the Centrifugal Compressor

Donald F. Crego
De Laval Steam Turbine Company

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ONLY a few years ago, if an engineer or designer had been asked how a compressed gas at 1000 psi might be prevented from escaping between the shaft and the compressor casing, he would have advised welding. Today, centrifugal compressors with modern sealing systems can handle even higher pressures in an increasing number of cross-country pipe line installations and in other applications throughout the petroleum and chemical industries. In many of these installations the modern centrifugal compressor has replaced the reciprocating unit.

The shaft seal is a critical component of the centrifugal compressor, and the success of the compressor today is largely due to the effective sealing arrangements devised by compressor manufacturers.

The manufacturer's approach to a specific sealing problem is governed by his knowledge of, and experiences with sealing systems. Equally important is the information provided by the propective user on his sealing requirements and operating conditions. The purpose of this review of seals and systems is to illustrate the importance of the information provided by the prospective user and to broaden the fund of existing information on centrifugal compressors, which have proved so eminently successful.

The Labyrinth Seal

The straight pass labyrinth seal is regarded as a fundamental device. (See Fig. 1.) In essence, it acts to impede the flow of a gas in a manner analagous to the orifice in a pipe. By a dissipation of the velocity head, the gas pressure is diminished. Leakage corresponds roughly to the laws of orifice flow.

In any gas sealing problem, some consideration should be given to the labyrinth seal in view of its low cost and reliability. This seal does permit considerable leakage. however. Table 1 shows the relative leakage allowances for different types of seals. The labyrinth seal is given the base index of 100.

Refinements of the basic design are shown in Fig. 2 and 3. The straight pass labyrinth is useful for a low cost, low pressure air or flue gas compressor. The staggered labyrinth is specified for applications involving higher pressures, and a segmental type of labyrinth would be more

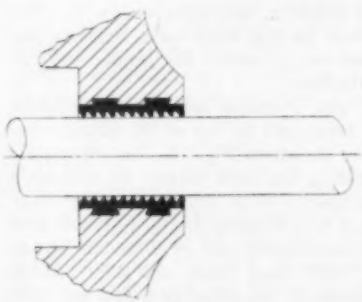

FIG. 1.

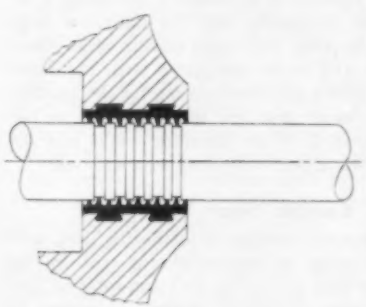

FIG. 2.

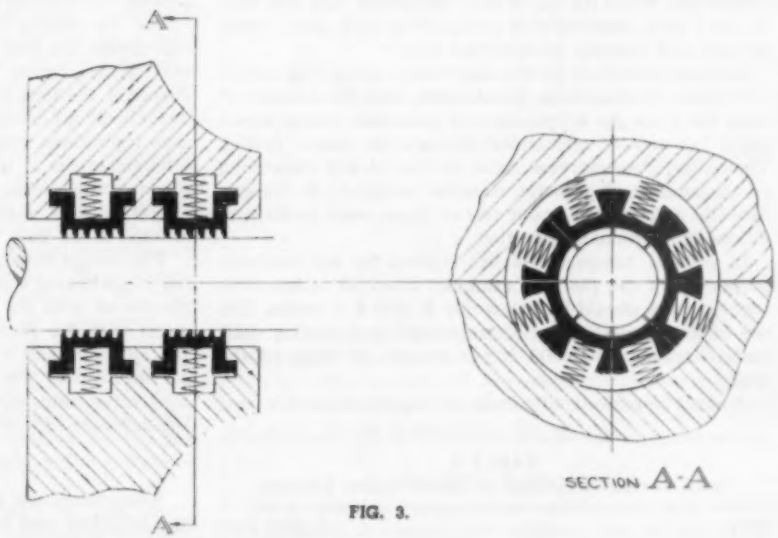

FIG. 3.

FIG. 1. Straight pass labyrinth seal.
FIG. 2. Staggered labyrinth seal.
FIG. 3. Segmental labyrinth.

efficient in handling high temperature air or exhaust gas since it maintains almost constant clearances throughout a wide temperature range, thus minimizing the effect of thermal expansion.

Clearances of fixed labyrinth seals are governed by manufacturing tolerances and are also affected by journal bearing clearances, thermal expansion and the vibration of the unit under operation. The clearance is usually so regulated that a slight interference between the knife points and the shaft will take place during the run-in period. With further use, this clearance inevitably increases to at least .015 in., and often more.

Segmental Carbon Ring Seal

The segmental carbon ring seal has been used extensively in steam turbines for tight sealing, conservation of space, and the reduction of shaft length which its use enables. Its design has taken several forms, varying in complexity from a simple rectangular cross-sectioned carbon ring and garter spring to the improved patented design shown in Fig. 4, in which the seal supports its own weight when the proper operating position has been reached. Wear is reduced and life increased.

The ring restricts leakage by dissipating gas pressure through the friction developed along its clearance walls. The principle is analogous to the pressure drop effected by friction through a long pipe of small bore. A well-designed labyrinth seal, occupying the same axial space would permit roughly four times as much leakage. (See Table 1.)

Pressure differentials as high as 150 psi may be obtained across each carbon ring. It is particularly applicable to flexible shaft machines as it is not seriously affected by the radial oscillations developed when the unit is passing through a critical frequency. Clearances are not increased as they would be in a labyrinth seal.

The segmental carbon ring seal is also useful when ambient temperatures are elevated. It will be recalled that in such a case, the clearances of the labyrinth seal are increased, allowing greater leakage. However, the clearances of the carbon seal decrease as temperature rises because its coefficient of expansion is less than the coefficient of expansion of the shaft.

The application of the segmental carbon ring seal, as an independent unit, is limited to compressors dealing with a clean gas. When the gas is dirty the carbon ring seal may be used very effectively in conjunction with other types of seals and systems, as described later.

Leakage permitted by the segmental carbon ring seal is a function of clearances, gland width, and the number of rings for given gas properties and pressures. Design clearances are usually maintained through the run-in period. Thereafter, they increase more or less slowly depending on the amount of abrasive material contained in the gas. Seal life is in general about two or three years under conditions of continuous operation.

In general, tempertaures are limited by the oxidizing porperties of the gas. For example, when air is involved, temperatures should be below 600 F, 900 F if steam. The use of these seals is possible in compressors having shaft surface speeds of 15,000 ft per minute, or more, at the seal.

A most important advantage of segmental carbon ring seal designs and labyrinth designs is that they are easy to inspect or replace. A cap is removed and the segmental elements may be slipped out.

Costs of carbon ring assemblies have been progressively reduced by a trend toward the standardization of rings. The gland box, however, in which the carbon rings are positioned, is ordinarily a design built to meet individual specifications and its cost will vary with the quantity ordered.

TABLE I.

Index of relative Leakage for Single Sealing Elements

SEAL	Leakage Index
Straight Pass Labyrinth	100
Staggered Labyrinth	56
Segmental Carbon Rings	20
Dry Contact Seal	2

The Bushing Seal

Although the segmental carbon ring seal is, in principle, a bushing seal, attention is brought herein to other types of bushing seals for use in sealing both liquids and gases. For the sealing of liquids, long bushings have been used for many years as interstage seals for water pumps. They have also been used in combinations with other seals in fluid injection sealing systems for high pressure gas compressors as will be described later. (See Fig. 11 and 12.) With lubricating oil as the fluid, the bushing offers almost indefinite life. With water, the life depends upon the amount of particle contamination in the water and the ability of the design to maintain a sizable film clearance between shaft and bushing bore.

In principle, the bushing acts as a seal by reducing pressure through friction along the annular clearance walls. Entrance and exit velocity losses contribute in small order. Mechanically, the bushing must be permitted to float radially with the shaft, therefore requiring a lapped sliding joint on the face of the bushing with the stationary housing. In some cases, where very small clearances between shaft and bushing are required, and where precise alignment cannot be maintained, the design must allow angular adjustment as well as radial motion. In these cases, a lapped spherical joint must be provided between bushing and housing.

The performance of the fluid bushing using L/D ratios of between 0.5 and 2.0, with clearances of 0.100 to 0.200 in. per inch of diameter and sealing against 1000 psi of lubrication oil, will offer leakages of a few gallons per minute, even at surface speeds of 10,000 ft per minute. Performance of bushings, under the same conditions, but with clearances in the order of 0.005 in., will offer as low as a few gallons per day leakage. In this latter case, extreme precaution must be given to provisions for proper support, cooling and filtering the fluid.

For the sealing of gas, a unique and effective bushing seal design has been developed by one of the independent seal manufacturers, as shown in Fig. 13. For descriptive purposes, the long bushing has been broken up into many small bushings called floating rings. Recognizing that clearance limitations with a long bushing primarily result from inherent errors in manufacturing and in alignment, a narrow bushing should lower these limits and offer reliable operation with clearances in the order of a few ten thousandths of an inch.

The design shown consists of alternately arranging floating rings having close clearances with the shaft and large clearances with the housing, and rings having large clearances with the shaft and close clearances with the housing, all positioned within a suitable housing for the particular application. The design was first made for sealing turbine valve stems against 2000 psi pressure and is now being developed for rotating shafts in many applications.

Contact Seal

The contact seal is a mechanical seal differing from both the labyrinth and bushing, or segmental ring seal, in that mating proximity between a rotating and non-rotating part is made possible under controlled mating pressures by springs. Referring to Fig. 5, the design consists of a shoul-

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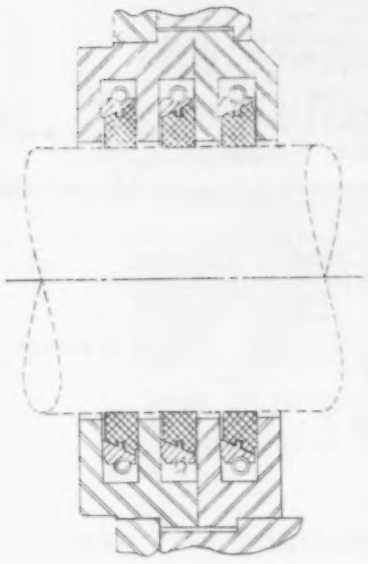

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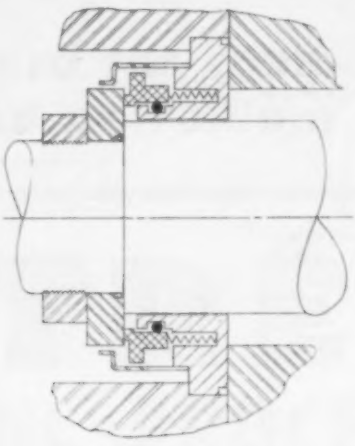


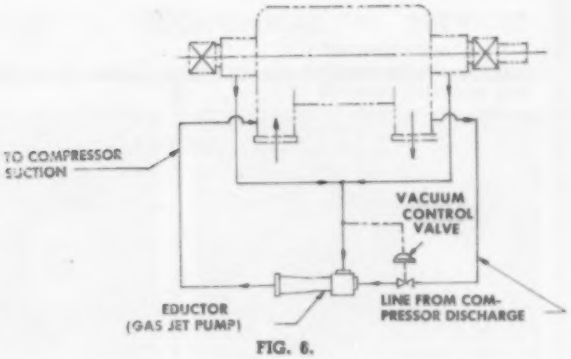
FIG. 5.

FIG. 4. Self-positioning patented segmental carbon ring.

FIG. 5. A contact seal.

FIG. 6. Self-contained evacuation system.

FIG. 7. Evacuation system in which the educted gas goes to the atmosphere.



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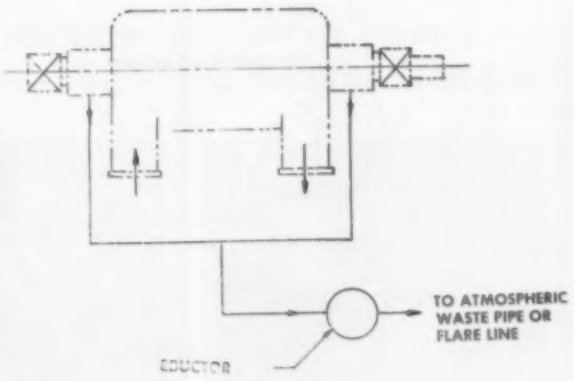

FIG. 7.

der or collar affixed to the shaft with a non-rotating seal ring positioned against the collar by springs. This non-rotating seal ring is free to float in both the radial and axial directions.

This basic arrangement, in more or less a crude form, has been used for many years as a fluid seal in centrifugal pumps. A refinement of its design, with particular attention to the control of mating pressures between stationary and rotating elements, has proved its feasibility as a very effective seal for gases without requiring fluid lubrication or cooling. This design is referred to as the Dry Contact Seal.

The sealing elements are usually made of a refined grade of carbon for the stationary seal ring and a stabilized hardened steel as the rotating ring. This combination naturally would have temperature limitations similar to those applied to the segmental carbon ring seal mentioned above. Structurally, the carbon element should be given strength and rigidity such as shrinking the carbon within a steel ring. The entire seal assembly should be arranged as a cartridge, thereby avoiding the necessity of handling the carbon element or damaging the multiplicity of springs and internal parts during shipment.

The designer is now selecting this seal for applications requiring strict limitations on leakage, either in or out of the compressor, and also where sealing oil systems requiring external facilities and controls are not desirable. Successful records of operation in wind tunnel compressors with highly de-humidified air and in chemical process compressors have proved outstanding advantages of effecting an almost perfect seal. See Table 1 for comparison to other seal designs. It is almost unaffected by shaft vibrations. Wear in applications with a clean gas will be less than .001 in. per thousand hours offering a life expectancy up to three years of continuous operation. These seals have operated successfully with pressures up to 100 psi at surface speeds of 25,000 ft per minute and at pressures up to 400 psi at reduced speeds.

Refinements of this contract seal design for fluid applications such as with an SAE 15-30 lubricating oil have been proved in a large number of pipe line compressor applications with surface speeds up to 10,000 ft per minute, in combination with a bushing seal employing a pressurized fluid sealing system sealing gas at 1000 psi. Wear has been found to be less than .0006 in. per thousand hours, offering a life in excess of five years of continuous operation. The seal is able to withstand severe radial vibrations and axial shocks inherent in this service.

Sealing Systems

The Evacuation System. The evacuation system, shown in Fig. 6 and 7, requires the combined use of two of the single sealing elements, either labyrinth, carbon rings, or dry contact seals. It evacuates the gas from between the two seals, reducing the pressure below both the pressure

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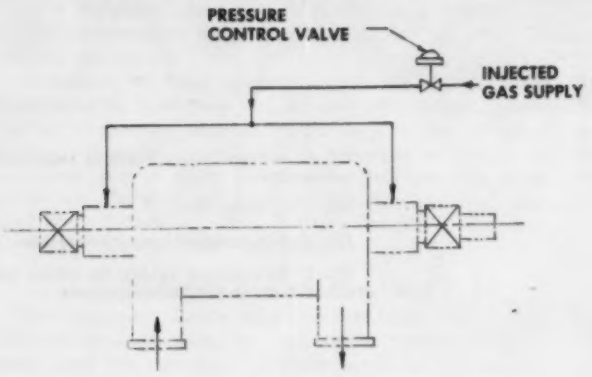

FIG. 8.

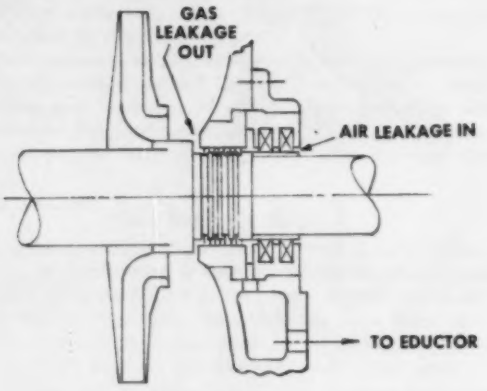

FIG. 9.

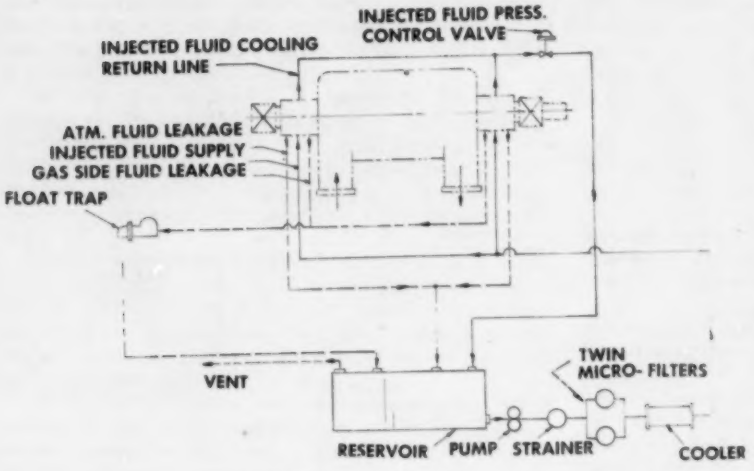

FIG. 10.

FIG. 8. Gas injection system.

FIG. 9. Double seals — contact and carbon rings.

FIG. 10. Fluid injection system.

FIG. 11. Fluid injection system.

FIG. 12. Double seals — contact and bushing for injection system.

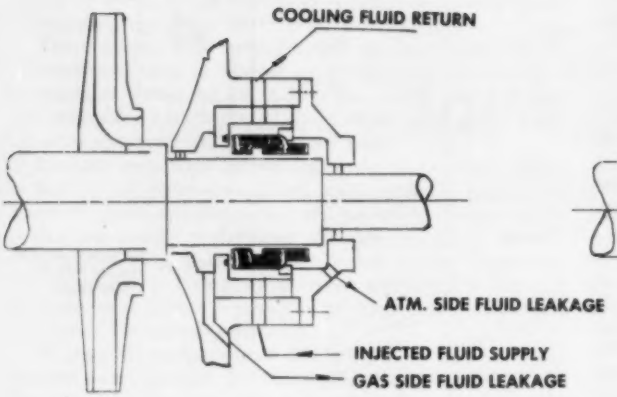

FIG. 11.

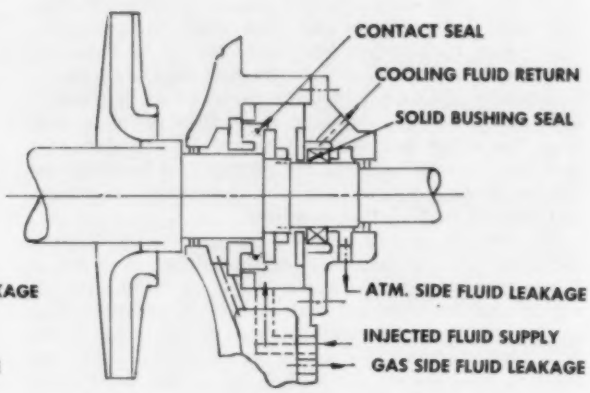

FIG. 12.

of the compressor gas at the seal and the atmospheric pressure. No compressed gas escapes to the atmosphere at the compressor. Air would, of course, penetrate the educted chamber from the atmosphere and contaminate the compressed gas being blown off to the eductor. Depending on whether contamination may be permitted, educted gas is either returned to the compressor suction, as in Fig. 6, or wasted by expulsion to the atmosphere through a flare pipe, as in Fig. 7.

Whether the labyrinth, carbon ring, or dry contact seal is selected is decided by the permissible in-leakage of air, the need for recirculation of gas leakage, abrasive particle content of gas, speeds, pressures, and temperatures. The eductor may be operated either by some external means such as air or steam, or by a velocity ejector employing pressurized compressor discharge gas. In either case, the loss of horsepower that is incurred by recirculating gas, upon which work has been expended, must be minimized. In typical cases, this loss may account for 2 to 6 per cent of the power required to drive the compressor, depending

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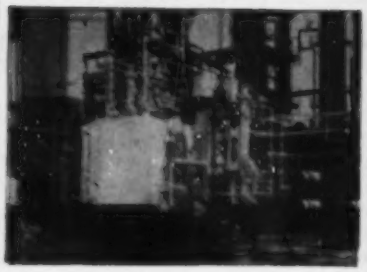

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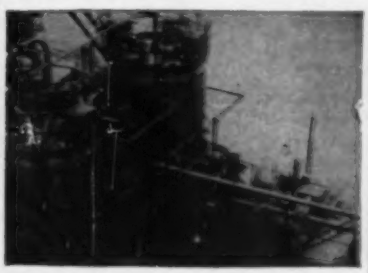

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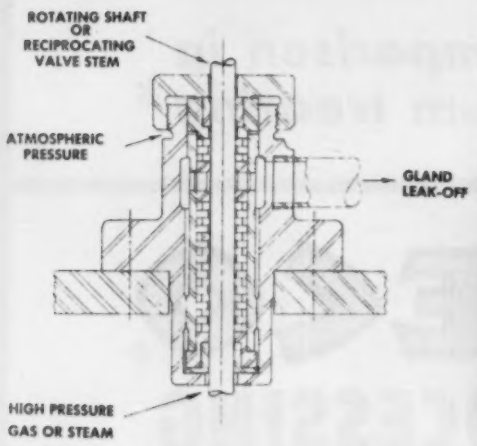

FIG. 13. Multiple bushing or floating ring seal assembly.

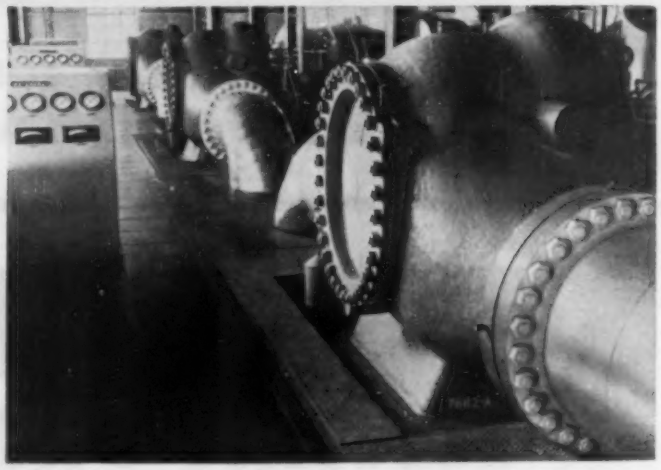

FIG. 14. Three 30-inch centrifugal compressors operating at the Florida station of El Paso Natural Gas Co. Nine more such units are installed in other El Paso stations.

on gas pressures and characteristics, and the size of the installation. It is evident that by reducing leakage through the use of carbon rings or dry contact seals, this power loss would be diminished. The principal advantage of the eduction plan is that it does not require a high capital investment, and it offers the possibility of a self-contained system relatively free of moving parts.

The Gas Injection System. A typical gas injection system is shown in Fig. 8. Double labyrinth sealing elements are usually employed. Other combinations of the single seals, shown in Fig. 1 through 5, have also been used, contingent on the amount of injection gas that may be allowed to leak to the atmosphere and into the compressor.

The gas injection system functions by injection gas, such as an inert combustion product (CO_2 and air) or nitrogen, between two sealing elements at a pressure slightly higher than the compressor gas so that the injected gas leaks into the compressor and no compressor gas is able to leak into the atmosphere. The principle is particularly adaptable with the contact seal since the injected gas may be conveniently filtered.

The gas injection system has been used by the refinery industries to totally seal flammable and toxic gases. Recent installations in the chemical process industries use the contact seal in conjunction with the carbon ring assembly shown in Fig. 9. Many thousands of hours of trouble-free service have been recorded to date.

The Fluid Injection System. The fluid injection system, shown in Fig. 10, is a firmly established system accepted for high pressure pipe line installations. It is now being most frequently employed on cat cracker gas applications. Historically, the plan has been employed for many years as the water seal for coke oven gas compressors where water is injected between two slinger, or segmental ring type sealing elements, at pressures slightly higher than the gas pressure.

The designer favors this type of seal for high pressure and refinery applications because he found it inadvisable to employ the use of a dry seal. Combinations of two single sealing elements are employed—such as contact seals, bushings, or even segmental carbon rings used as fluid seals. The injected fluid is usually oil, although other fluids may be used as dictated by specific requirements. The oil is filtered, cooled, and pressurized to a pressure slightly above that of the gas pressure. Oil leakage usually takes place through both the atmospheric and gas sealing elements and is reclaimed and returned to the reservoir. In pipe line applications and other applications where the oil leaking to the gas side is not deleteriously affected by the gas, the oil may be used over and over again until the neutralization number indicates it has been spent. In rare cases, where the oil is exposed to a stronger toxic or sulfur gas, it may be discarded or reclaimed by outside facilities. If the seal on the gas side is properly selected, the amount of exhausted oil would be small, representing no more than a few dollars a day.

Two combinations of sealing elements are used most frequently with this fluid injection system. They are shown in Fig. 11 and 12.

Designers may differ in their approach to selecting the sealing elements. One approach would be to evaluate the characteristics of each element for its specific function and location. For example, on high pressure applications, the desirable location for the bushing element is on the more rigid journal bearing side of the combination where angular deflections are negligible, and at the same time, where appreciable oil leakages can be easily drained and collected and where they may be tolerated without exposure to gas. On the gas side, the contact seal may be preferred in view of its low leakage allowance and its insensitivity to shaft vibrations, particularly after machines have been in operation for some time.

Fig. 12 shows the injection system with a bushing and contact seal combined. Wear of the bushing on the atmospheric side, when provided with ample rotating clearances, has been found to be negligible, and the life of the system is very high. The contact seal also has an exceptionally long life. Wear measurements indicate a normal life expectancy of 50,000 hours before replacement of the carbon ring is required. The wet contact seal, like the dry contact seal, is almost unaffected by shaft vibrations and momentary rough operation. In addition, it offers reliable service under abnormal operating conditions where pressure of the injected fluid is not maintained above the level of the gas pressure.

The above review should indicate that rapid progress in seal development for the centrifugal compressor field has well fortified the designer to handle new applications and thereby broaden its use. It should be recognized, however, that whatever the problem may be, the designer must interpret and analyze the information given by the prospective customer through his sales forces. Therefore, every effort should be made to clearly define the sealing requirements and to specify as realistic limitations as possible.

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P 721.338

How do you measure accurately pelleted catalyst, in moving bed catalytic crackers?

Level Measurements in GRANULAR SOLIDS

Francis S. Becker
Chief Instrument Engineer, Sun Oil Company

LEVEL measurement in granular solids such as grain, Fuller's earth, pelleted catalyst, etc., has increased in importance in many industries but is probably of greatest importance to the petroleum industry with the advent of catalytic cracking units using granular catalyst in a moving bed operation.

In one design of moving bed catalytic cracking unit, the height of the catalyst in the reactor hopper is used as a seal to prevent hydrocarbon vapors escaping from the reactor to the atmosphere. It is extremely important therefore, to be able to record and control the level of the catalyst in the reactor hopper for safe and proper operation of the unit. It is also desirable to record the level of the catalyst bed in the reactor itself because the correct contact time of the hydrocarbon vapors with the catalyst is dependent in part on the depth of the catalyst bed through which the hydrocarbon vapors flow.

The first automatic gaging devices for granular catalyst were mechanical in design. One such device widely used in the early development of moving bed catalytic cracking units operated somewhat like a "Yankee" ratchet type screw driver. A long probe of spear with a heavy conical-shaped head extended down into the catalyst. The shaft of this spear had a long, tapered worm attached to it and was continuously driven by a motor with a worm gear which was rotated in such a way as to try to lift the spear out of the catalyst. As long as the spear was able to turn freely and was not supported by the catalyst, however, its own weight would propel it downward until it touched the catalyst. As soon as the spear touched the catalyst and the catalyst supported its weight, the motor would drive it up out of the catalyst and the above process would continuously repeat itself. The top of the spear was connected through a swivel to a cable that was linked to a motion transmitter that produced a pneumatic signal to a recorder or controller.

The above type level transmitter is still in use in some refineries.

Increased severity of operating conditions, such as temperatures of 900 F to 1100 F and the abrasive action of the catalyst, increased mantenance and decreased the reliability of mechanical devices to the point where it became necessary for the instrument engineer to look for other methods of measuring level in granular catalyst. About this time there appeared on the market, a new type of level instrument called a Gagetron, using the absorption of gamma rays from a radium source as an indication of level.

At first glance this instrument appeared to be the answer to an instrument engineer's prayer for all difficult level measurements. Further study, however, proved that much research had yet to be done with the operation and application of the Gagetron before it became the very important and useful tool that it is today for difficult level measuring applications.

The Gagetron was developed shortly after the atomic bomb and at a time when very little was known to the general engineering profession about nucleonics of gamma radiation.

One of the first and hardest obstacles to overcome in making the Gagetron a reliable instrument was the development of a reliable Geiger counter tube. Existing Geiger tubes on the market, which were mostly of the self-quenching type, had a fixed life of 10^8 to 10^{10} counts. In many level applications this meant that the maximum life of the Geiger tube was only 2 to 10 weeks; many tubes failed in less than 2 weeks. Geiger tubes as manufactured were anything but uniform in sensitivity, requiring recalibration of the Gagetron every time a Geiger tube was changed. Considerable resistance was encountered in getting the tube manufacturers to produce a better Geiger tube because existing tubes were good enough for most other applications.

Instruments, Inc., the manufacturers of the Gagetron were forced to design and build their own Geiger

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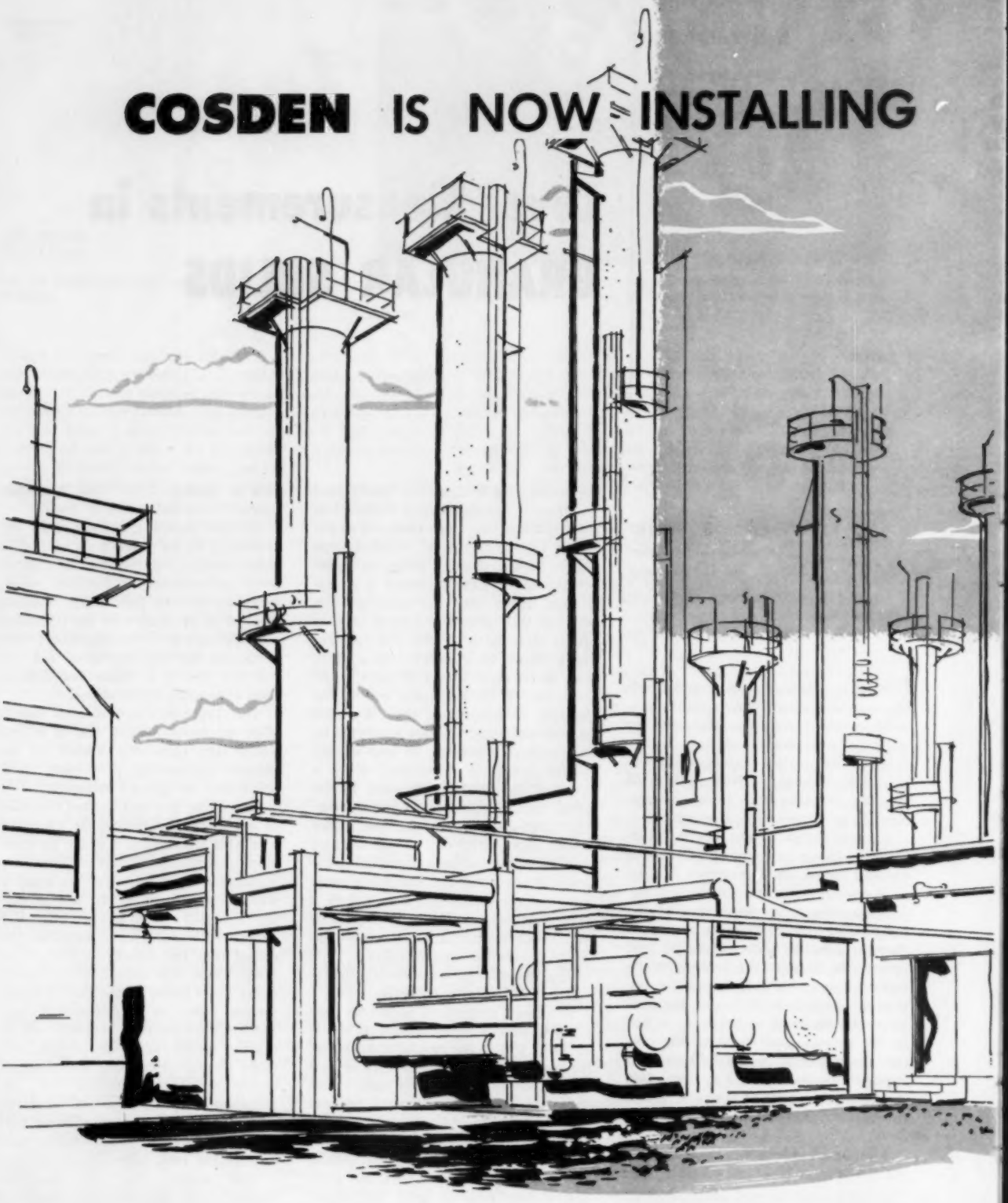

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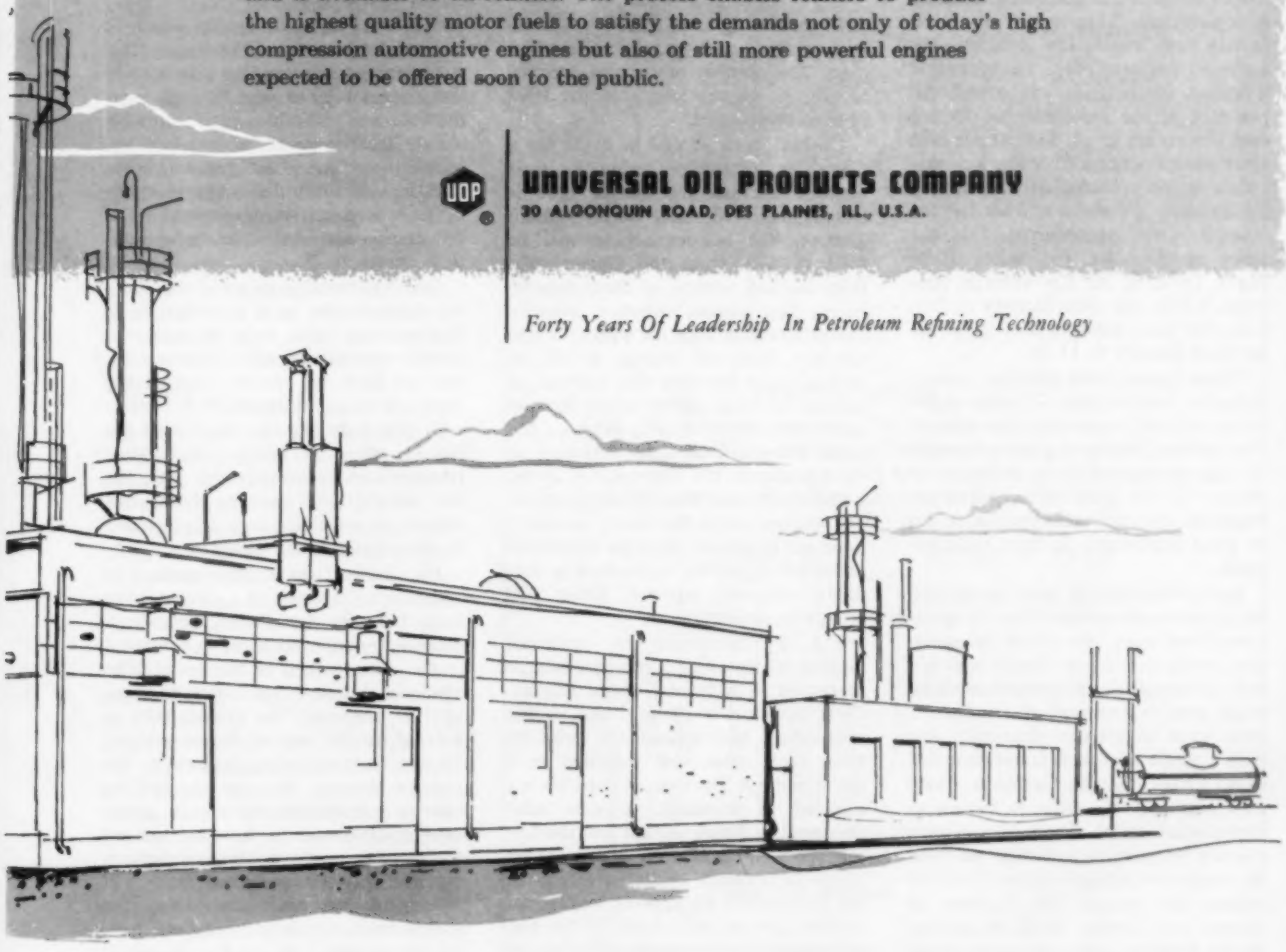

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tubes, which are of the external-quench type. These tubes have been perfected to the point of having a theoretically unlimited life and excellent uniformity. Many of these tubes have been in service continuously for two years.

In order to properly design and install a Gagetron level transmitter, it is necessary to have some knowledge of the fundamental characteristics of gamma rays.

Gamma rays emanate from a radioactive source much in the same manner as light rays from a light source, going out in all directions in straight lines, and like light rays, the intensity of gamma rays varies inversely with the square of the distance from the source. Gamma rays will penetrate any substance, but are absorbed in a greater or lesser degree depending on the density of the material through which they pass. The greater the density of the material, the more gamma rays are absorbed. The relation between absorption of gamma radiations and path length through the absorbing material is logarithmic. This means that if a certain path length, say 2 inches, absorbs 50 per cent, then an additional 2 inches of material will absorb 50 per cent of the remainder or 75 per cent absorption in all. The 50 per cent absorption thickness of a few key materials is very useful in determining the location of radium sources and the amount of radium required. This distance is 5.67 in. for water (density = 1), 2.52 in. for average concrete, 0.8 in. for iron (density = 7.8), 8 in. for bead catalyst, and 0.547 in. for lead (density = 11.3).

These figures hold true for gamma radiation from radium. If other radioactive materials are used the absorption will be greater. A certain number of gamma rays will be deflected or bounce off the back surface of dense materials but this phenomenon is not of great importance to level measurement.

Early development work done with the Gagetron determined that the maximum level span that could be measured using one radium source was two feet. Although the Gagetron could be made sensitive enough to measure a level span of greater than two feet with a single source, it is not practical to do so because the Gagetron would then also pick up what is known as background count. There is a certain amount of natural radiation all over the world amounting to about 35 to 100 counts per minute. The number of gamma rays coming from the radium source must be great enough to make the background count a reasonably small amount of the total count.

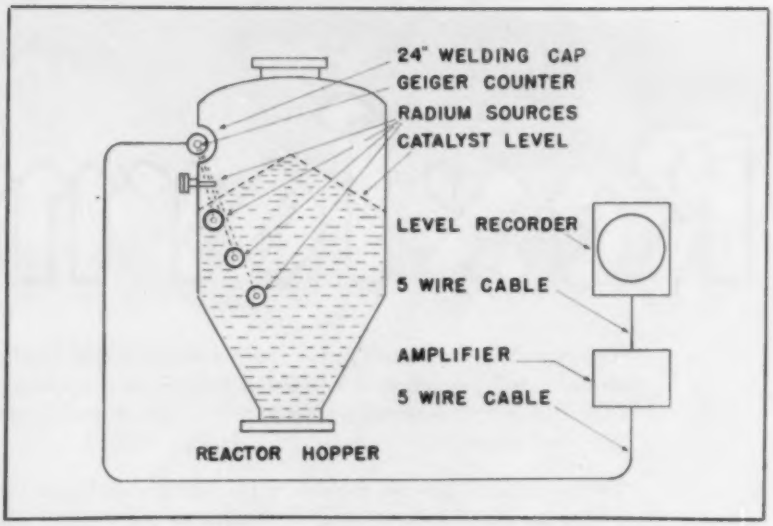

FIG. 1. Typical gagetron installation measuring catalyst level in a reactor surge hopper. The radium sources are in wells arranged in spiral pattern and the Geiger tube is inserted in a 24-in. welding cap above the top radium source.

In measuring level spans above two feet, multiple radium sources must be used. The number of sources depend, of course, on the length of the level span to be covered.

Careful study should be made for a Gagetron installation using multiple sources. Because the Geiger tube is usually mounted above all the radium sources, the bottom source will be farther away from the Geiger tube than the top source, so that, remembering that gamma radiation intensity varies inversely with the square of the distance from the source, it will be necessary to increase the amount of radium in each source below the top source in order for it to produce the same increment of level variation as the top source. The sum total of all the gamma radiation from all of the multiple sources when the vessel is empty must not be greater than the maximum count for which the instrument is normally designed, namely, about 100 counts per second.

Fig. 1 illustrates the preferred method of installing a multiple source Gagetron in a reactor surge hopper. Four radium sources are used in this application, each spaced 2 ft vertically from each other and mounted in a spiral pattern. The radium capsules are inserted in standard stainless steel thermowells which project into the vessel about 8 inches. A heavy blank flange is fastened to the outer end of the thermowell to prevent leakage of gamma rays to the outside of the vessel endangering the health of personnel working in that area. The Geiger tube is mounted 2 ft above the top source and in a 24-in. welding cap which is inserted in the side of the vessel. The curvature of the welding cap allows the gamma rays to pass through it in the shortest possible path through metal. Because 0.8 in. of iron will absorb 50 per cent of the gamma radiation, it is important to make the path through steel as short as possible to reduce the size of the radium sources to a minimum.

One disadvantage incurred in placing the Geiger tube in a welding cap is that extreme care must be taken to prevent the Geiger tube from getting too hot from the radiant heat of the vessel. A temperature of 200 F or over will materially shorten the life of the Geiger tube. In many installations, where excessive temperatures preclude the possibility of inserting the Geiger counter in a welding cap, it is fastened to the outside of the vessel.

Fig. 2 illustrates another method of installing a Gagetron on a reactor surge hopper. In this installation the radium sources are inserted in sockets welded to the outside shell of the vessel. The sources are mounted in a vertical plane at 2 ft intervals. The Geiger tube is located on the top of the vessel and 90 deg from the vertical plane of the radium sources. Because the radium sources are outside the vessel, heavy steel collars must be fastened around the radium source holders to prevent harmful gamma radiation from endangering personnel. Comparing the dotted lines, which represent the path of the gamma rays, on Fig. 1 and 2, you will notice that the paths are much shorter in Fig. 1 which means that

the installation in Fig. 2 will require more radium. The only advantage in installing a Gagetron as shown in Fig. 2 is that it can be installed on an existing vessel without shutting down the process.

Improved technique in the installation of the Gagetron together with improvements in the Gagetron itself, particularly in the integrating circuit which has reduced pulsation on the instrument from about ½ in. on the chart to less than ⅛ in. on the chart make the Gagetron an excellent level recorder in practically every difficult level application. Some difficulty has been encountered in using the Gagetron as a controller for catalyst level in reactor hoppers in moving bed catalytic cracking units, however, for the following reasons:

1. The design of the electronic integrating circuit introduces a lag in level indication of approximately 20 seconds.

2. The surface of a granular solid in a vessel is not flat like a liquid but is cone shaped; furthermore the center of the cone may be cratered to a greater or lesser degree if the withdrawal of the catalyst at any moment is greater than the incoming catalyst. This phenomena coupled with the inherent lag of the Gagetron may result in the recorded change in level being out of phase with the true level change. It is obvious that control is extremely difficult if the above situation occurs.

In order to overcome the difficulties encountered in using the Gagetron as a controller in some installations, experiments are now being conducted in the use of a capacitance type level instrument.

The Fielden Instrument Company has developed a capacitance type level instrument using an insulated probe as one plate of a condenser. The walls of the vessel act as the other plate.

Measurement of level change is accomplished in two ways, either way accomplishing the same net result of change in capacitance. If the material being measured is an insulator such as catalyst, the rise and fall of catalyst between the two plates of the condenser changes the capacitance in direct proportion to the level of the catalyst. The sensitivity with which this device will measure changes in catalyst level is dependent in part on the difference in dielectric constant of the catalyst and the air or hydrocarbon vapors above the catalyst.

There is not enough difference in the dielectric constant of air or hydrocarbon vapors to make any appreciable difference in the calibration of this instrument. If the material being measured by a capacitance type instrument is an electrical conductor such as sulfuric acid, a probe coated with teflon would be used with the teflon having a fixed dielectric constant while the rise and fall of the sulfuric acid in the vessel would have the effect of increasing or decreasing the size of one plate of the condenser which would, of course, change its capacity in proportion to the level change.

There are several capacitance type level instruments giving satisfactory results in liquid level applications and quite a few have been used for level measurement of cold catalyst in storage bins.

Fig. 3 illustrates a capacitance type level instrument designed by the Fielden Company for the measurement of hot catalyst in a reactor hopper. In this installation, the probe consists of a stainless steel wire passing through a quartz insulator at the top of the vessel and being fastened to the bottom of the vessel with a quartz-insulated turnbuckle. The walls of the vessel are used as the other plate of the condenser.

We were unable to accept this installation for the following reasons:

1. The maximum length of the coaxial cable from the probe to the electronic measuring unit was 10 ft, which meant that the measuring unit had to be mounted on the top of the vessel. Because this vessel is 350 ft high, servicing equipment on top of it becomes a major maintenance problem.

2. Experiments conducted on the dielectric constant of granular catalyst disclosed that it varied considerably with changes in temperature. At a frequency of 10 kilocycles the dielectric constant was 3.0 at 800 F, and 8.0 at 1100 F. Because the temperature of the catalyst can vary from 900 F to 1100 F in the normal operation of the plant, some method of automatic compensation for changes in dielectric constant is necessary for the successful measurement of level.

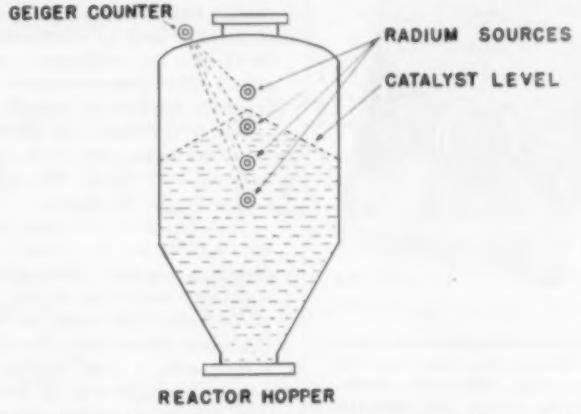

FIG. 2. Gagetron installation in a reactor surge hopper with radium sources mounted in a vertical plane on the outside shell of the vessel. The Geiger counter is located on the top of the vessel and 90 deg from the vertical plane of the radium sources.

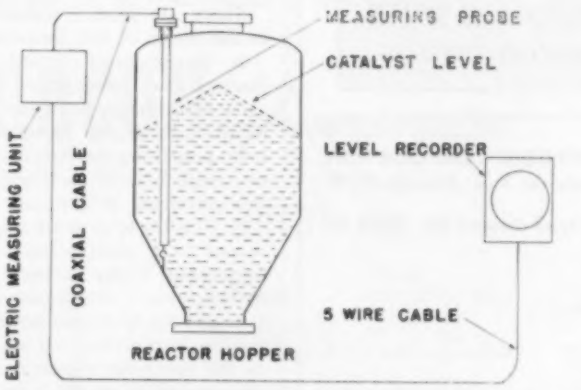

FIG. 3. Installation of capacitance type level recorder using probe as one plate of condenser and the vessel wall as the other plate.

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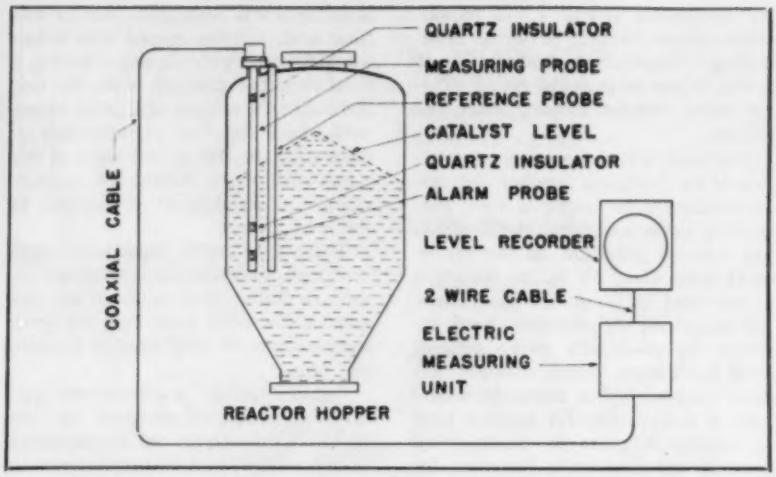

FIG. 4. Installation of capacitance type level recorder using two (2) probes as the plates of a condenser with a separate probe for low level alarm.

The Sun Oil Company's Physical Research Laboratory has been interested in the development of capacitance type instruments for the measurement of level for some time and has developed an instrument that overcomes difficulties encountered in measuring the level of hot granular catalyst.

Fig. 4 illustrates the installation of the capacitance type level instrument, designed by Sun Oil Physical Laboratory in a reactor hopper.

This design incorporates the use of two probes as the plates of a condenser; a reference probe consisting of a stainless steel tube or pipe grounded to the walls of the vessel and a measuring probe constructed of stainless steel tubing with a long insulated section for the measurement of level change and a short insulated section at the bottom for low level alarm. The connecting wires for the measuring probe are fed up through the hollow center of the probe to a terminal block in the head of the probe.

There are several unique features in the design of this instrument.

1. The electronic circuit has been so designed that the length of the coaxial cable from the probe to the electronic measuring unit can be up to 1000 ft long, permitting the installation of the electronic unit in the Control House for convenient maintenance.

2. The low level alarm probe is connected to a separate section of the capacitance bridge network in such a manner that if the measuring probe fails and the level goes down as far as the low level probe, or if anything fails in the electronic circuit connected to the measuring probe, it will give an alarm.

3. Incorporated in the design of the probe is an automatic compensator for changes in the dielectric constant of the catalyst with changes in temperature.

At this point it might be of interest to compare the cost of the level transmitters discussed.

Gagetron — $3,500.00
Fielden — $1,000.00
Sun Oil — $1,000.00

The above prices are for probes and electronic equipment only and do not include accessories such as recorders, controllers, or in the Gagetron, the price of the radium sources.

Conclusion

In conclusion, we believe that both the Gagetron and the capacitance type level measurement of granular solids are important and reliable tools for the industry.

The Gagetron will safely measure level in the most difficult and hazardous process thus far devised and has the advantage that it can be repaired or replaced without shutting down the process.

The capacitance type level instrument will give a more accurate and constant level reading in those processes where a probe can be designed to withstand the operating conditions involved and to stand up for reasonable periods of time before it is necessary to shut down the process and replace the probe.

Acknowledgments

The writer wishes to acknowledge his indebtedness to E. J. Grace, E. J. Grace Company, and L. Foester and N. Shawn, Sun Oil Company, for their cooperation in collecting data and giving constructive criticism.

References

1. Technical Report, Research Department, Instruments, Inc.

★ ★ ★

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WORLD-WIDE CONSTRUCTION FOR THE PETROLEUM, PETROCHEMICAL, AND CHEMICAL INDUSTRIES

INSTRUMENTATION

Electronic Instrumentation for Atlantic Catformer

Dependable operation, low first cost, less maintenance are marked advantages of this system

F. C. Somers, R. C. Fuhs
Atlantic Refining Company

THE Atlantic Refining Company has "on stream," since August 1954, an 8000 bbl per day Catformer at its Atreco Refinery in Port Arthur, Texas, instrumented with an electronic control system. During the preliminary stages of the design of the Atlantic Catformer at Atreco, Atlantic's engineering and construction department decided that recent developments in instruments and controls, particularly along electronic lines, justified a reappraisal of Atlantic's instrument practices and a thorough evaluation of available equipment of both the pneumatic and electronic types. The reappraisal indicated that a first-class, thoroughly modern installation should satisfy these requirements:

a) Operate dependably and accurately.

b) Offer low first cost. As the number of instruments and controls has increased, the cost of the equipment and interconnections has required closer scrutiny. The skilled labor required for the tubing work between pneumatic transmitters and controllers, plus the costs of such auxiliaries as air compressors, filters, driers, indicated there should be less costly ways of doing the job.

c) Require minimum size control house. That the trend in control houses is strongly in the direction of larger and more elaborate buildings is apparent to all. Unfortunately, the consequences in terms of overall cost of the instrument installation are not always appreciated.

d) Require minimum operating personnel. Some instrument panels cover so much space that they require the attention of several operators.

e) Require less maintenance and be easier to maintain when maintenance is required.

f) Be adaptable to incorporating probable future developments in the field of automation.

All photos courtesy Atlantic Refining

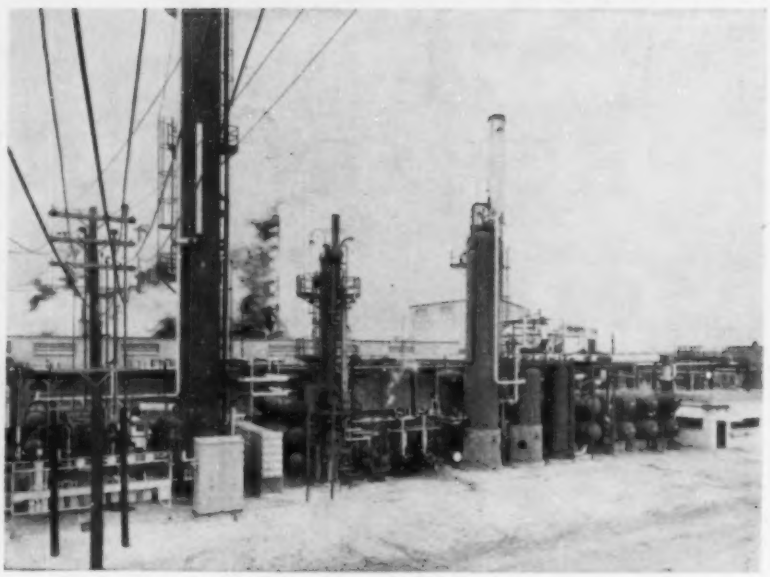

FIG. 1. General view of Atlantic's 8000 bbl per day Catformer unit at Atreco.

A careful evaluation of available instruments and controls led to the conclusion that an electronic instrument system fulfilled the above requirements more nearly than a pneumatic system. Although operating experience was practically non-existent at the time, the marked reduction in moving parts and the inherent accuracy and absence of time lag in electrical measurements led to the conclusion that the operation of an electronic system was potentially

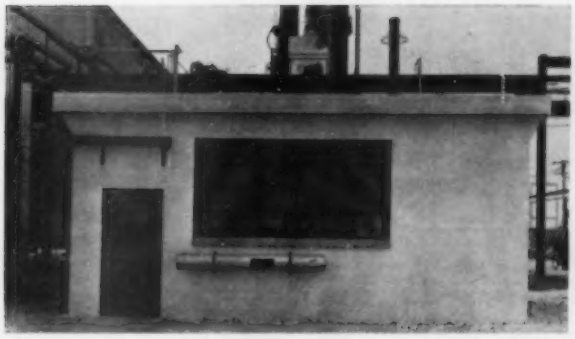

FIG. 2. Control house at Catformer.

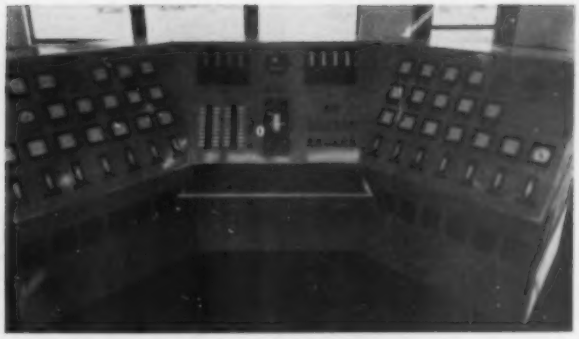

FIG. 3. Front view of console of control system.

more dependable, as well as more accurate. Economic studies indicated the installed cost of the electronic system was about 12 per cent less than for an equivalent pneumatic system. Equipment costs were not significantly different. Differences in installation costs, and particularly the differences in the cost of electric wiring versus pneumatic tubing, accounted for much of the saving. A number of possible control house layouts using the various types of instruments were investigated, and it was concluded that electronic instruments in a console arrangement would result in minimum size control house.

Employing electronic instruments in a console arrangement produces an extremely compact arrangement with all instruments and controls readily visible and accessible to a single operator. As can be seen from Fig. 3, the console is not much larger than a conventional desk. Such compactness and accessibility is most desirable when operating the plane with a minimum number of shift operators.

The fact that electronic instrument equipment has few moving parts, none of which are delicate, points in the direction of less maintenance. The "plug-in" feature of electronic instruments and controllers, in conjunction with the fact that control action can be present to desired values without cut and try adjustments after installation, make interchanging units a simple matter. Thus most maintenance work can be performed under favorable shop conditions.

Virtually all foreseeable future advancements, such as automatic data gathering systems, are based on converting the measured quantities to electrical units and from this standpoint, the electronic equipment is particularly advantageous.

The electronic system appeared superior on all points, but there was not sufficient operating experience available to substantiate the conclusions. The potential advantages appeared great enough to justify pioneering a full-scale installation, however. Accordingly, Atlantic's engineers, in conjunction with the H. K. Ferguson Company, proceeded with the design and installation of an electronic instrument and control system for the Catformer at Atreco.

The Electronic Instruments

The electronic system employed is the Swartwout Autronic Control system. The basic principle of this system is the conversion of a measured variable to a 0 to 0.5-v, 60-cycle, a-c signal in the primary element or transmitter which is mounted near the measuring point. This signal voltage is transmitted to the recorder or indicator in the recording systems, or to the recorder and controller in the contol systems. The coatroller converts the difference be-

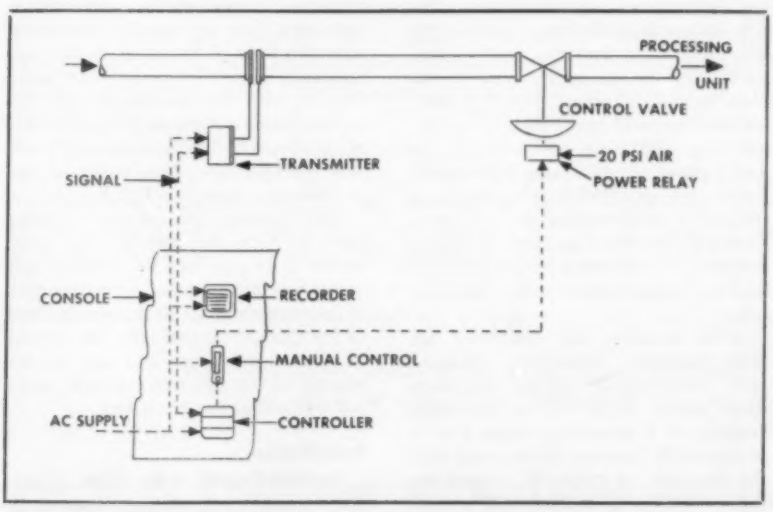

FIG. 4. A block diagram of the typical flow system.

FIG. 5. The pressure transmitter with and without cover.

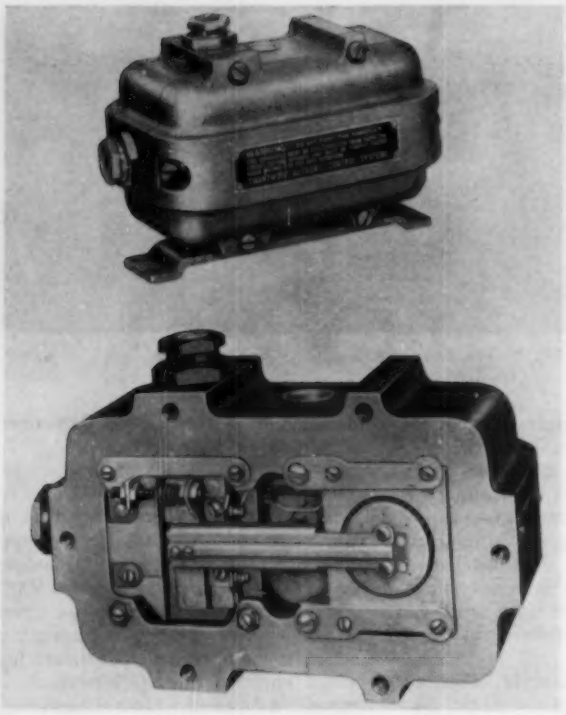

FIG. 6. Power relay with and without cover.

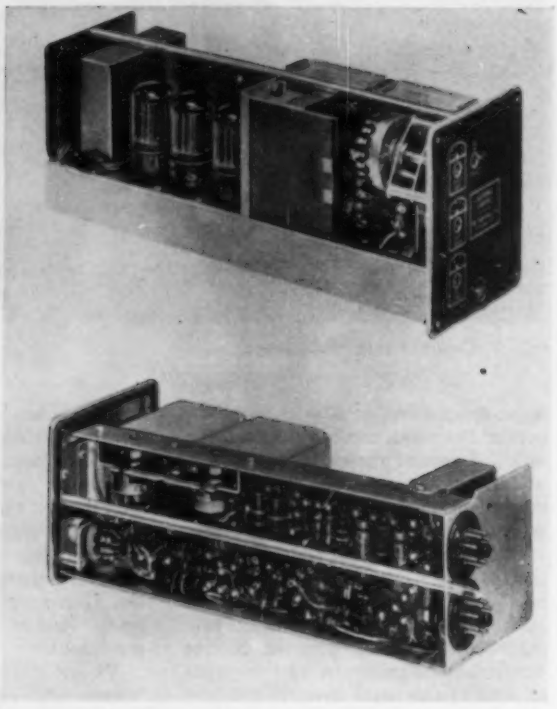

FIG. 8. Side and bottom views of controller chassis.

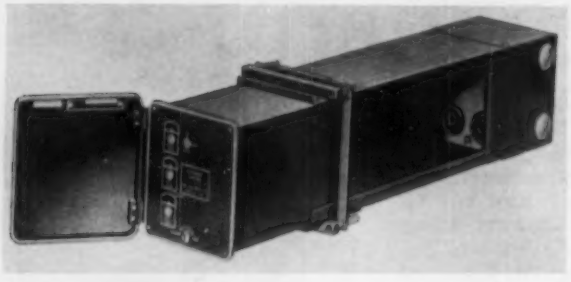

FIG. 7. The controller partially removed from its mounting frame.

tween the transmitter signal and the set point signal to a d-c current. This current is transmitted through the manual-automatic selector switch, called the manual control, to the electric to pneumatic transducer, called the power relay. The air from the power relay actuates any standard diaphragm valve. The recorders, controllers, and manual controls are located in the central control house, while the power relay is mounted near its control valve. A block diagram of a control system is shown in Fig. 4.

The mechanical design of instruments is a factor that is often overshadowed by considerations of operating principles and potential performance. Actually, sound mechanical design is the most fundamental consideration of all. It is the basic requirement for peak performance, stable operation, and reasonable maintenance. In selecting instrument equipment for this project, mechanical design received the consideration it deserves, and it is believed that the equipment used is outstanding in this respect. Fig. 5 shows a transmitter with and without cover, and Fig. 6 shows a power relay with and without its enclosure cover. Both devices are mounted in substantial cast enclosures approved for use in Class I, Group D, division 1 location. Attention is directed to the small number of parts and the rugged construction throughout.

Both recorder and controller are flush mounted, miniature, "plug-in" type, designed to require minimum panel space. A recorder or controller consists of a mounting frame that is permanently fastened to the panel with the recorder or controller proper being assembled as a removable chassis that plugs into the mounting frame. All external connections are made to a terminal strip at the rear of the mounting frames. Connections from the mounting frame to the removable chassis are made through a plug and socket arrangement very much like the plug and socket of the familiar radio tube. This construction permits the controller and recorder to be easily removed from its mounting frame without disturbing any external connections. Fig. 7, a photograph of the controller partially removed from the mounting frame, shows the "plug-in" socket of the mounting frame and the controller adjustments that are readily accessible from the front of the panel. A side and underside view of the controller chassis, Fig. 8, with the dust-proof case removed points out the neat arrangement of components that permits simple test and maintenance. Two views of the recorder are shown in Fig. 9.

The absence of delicate moving parts in both the recorder and controller is in contrast to constructions commonly encountered in other types of instruments. Fig. 10 is a photograph of the manual control unit. The unit is in its own enclosure and may be removed for repairs and replaced without disturbing the controller.

Installation

General Layout of the Plant. A general view of the Catformer is shown in Fig. 1. The fractionating section is

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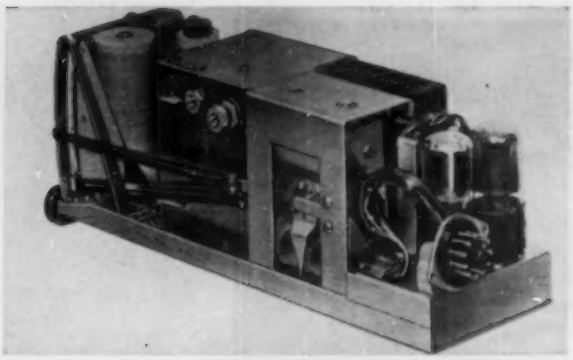

FIG. 9. Rear view of recorder chassis.

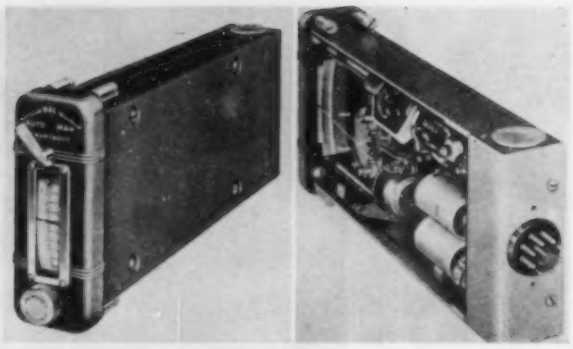

FIG. 10. Front of manual control, and rear with cover removed.

shown in the foreground with the control house in the right corner. In the background may be seen from left to right, the compressor house, the reactors, and furnaces. A 12-ft wide accessway running the length of the plant is located between the fractionating section and compressor house. The plot is approximately 200 ft long by 120 ft wide. The instruments and controllers are centralized in the control house. An overhead metal cable way extending from the control house down the length of the accessway between the compressor house and the fractionation section carries the interconnecting wiring.

List of Instruments. A complete list of the instrumentation installed is as follows:

(1) Twenty recording systems, consisting of nine flows, six pressures, and five temperatures. (Electronic Transmitters and Recorders)

(2) Fourteen controlling systems, consisting of six flows, five pressures, and three temperatures. (Electronic Transmitters, Recorders, and Controllers)

(3) Forty thermocouple points. (Read on an electronic type indicating potentiometer).

(4) Four liquid level indicators and controllers. (Pneumatic type)

(5) Four liquid level controllers. (Pneumatic Controllers—locally mounted)

(6) Two high level alarms. (Triggered by float-actuated switches)

(7) The operation of all compressors and pump drives is monitored by running lights.

(8) A cooling tower low water level and gas alarm.

(9) Speed controllers on the four compressors. (Pneumatic—locally mounted)

With respect to items 4 and 5, pneumatic liquid level controllers were selected because a suitable electronic instrument was not available. Two of these level controllers are "blind" controllers, while four have the level indicated on the console. These four levels are the only signals pneumatically transmitted to the control house. Pneumatic speed controllers were chosen because they are completely locally mounted instruments, and electrical transmission and control was not considered necessary.

Control House and Console. All instrumentation, with the exception of the compressor speed controllers, is mounted in a console type panel located in the control house. A photograph of the console is shown in Fig. 3. The panel instruments are the miniature, "plug-in" type and lend themselves to console arrangement. The console arrangement is something of a departure from the currently popular graphic panel arrangement. Graphic panels may have some initial advantages in training and familiarizing the operators with the plant, but these advantages are only temporary at best. The higher first cost, excess building space requirements, and general lack of convenience in operation as compared to a console are disadvantages that continue for the life of the plant. A console has the advantages that all controls are visible to the operator at a glance, and it can be fabricated, tested, and shipped as a complete unit. This latter feature greatly eases the installation problems, as only a comparatively simple field recheck is necessary.

Although it is often overlooked when estimates and comparisons are made, the cost of the control house is a large part of the total instrumentation investment. As an example of the economies that are possible by a combination of miniature instruments in a console arrangement, the control house for this plant, which is pictured in Fig. 2, is only 14 by 25 ft inside. The area of this house is only 350 sq ft as compared to 900 sq ft required for another recently constructed Catformer using standard size pneumatic instruments.

Normal Instrument Power System. The console presents a load on the 115-v system of approximately 1500 va. This power is fed by one circuit, but in the console it is subdivided into two main groups.

(1) The instruments, which are fed through a 2000-v amp constant voltage transformer.

(2) Accessory equipment (clock, running lights, etc.), which is fed directly from the line.

The constant voltage transformer serves as an isolating transformer, as the instruments have one side of their power circuit grounded and are being fed from a 115-v ungrounded system. The instruments are the null balance type and are not affected by nominal voltage variations; hence the constant voltage feature is not absolutely essential.

The power supply circuit, along with all the power and signal wiring from the transmitters and power relays, is brought to the console through a single metal cableway. See Fig. 11. All circuits terminate at terminal blocks in distribution boxes located in the console.

The controllers and recorders have internal circuit protection; however, additional protection is required to isolate separate systems from the main feeder. In the recording system, the circuit protection is arranged to isolate both the recorder and its associated transmitter in case of failure of either. The protection for the control system removes the transmitter, recorder, and

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PETROLEUM CHEMICALS DIVISION
NEWS

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February ★ *One of a Series of Interest to the Petroleum Industry* ★ *1956*

Question Box

Want to get your TEL-handling people to think of safety "as a way of life"? Then you'll be interested in reading about the Du Pont Lead Hazard Clinic.

What makes a construction safety program, and what are the returns on a safety investment? To obtain a print of the movie that gives the answers, see the article on our film, "Builders of Tomorrow."

Who heads the Petroleum Chemicals Division Eastern Regional Lab? We'd like you to meet *Ed Jeffus.*

Have you heard about the oil industry's "best seller"? See the story about "Speak to the Earth."

THE DOLLARS AND CENTS OF SAFETY

New film of interest to refinery construction personnel

"The Builders of Tomorrow" is the title of a film about accidents that never happened. More importantly, it illustrates how and why they never happened.

This 28-minute color movie was made on location as the Du Pont Engineering and Construction Division erected the A.E.C.'s Savannah River Atomic Energy Plant in Aiken, S. C.

This plant, a 4½-year task, involves massive equipment, thousands of workers and many different hazards. It is one of the largest and safest construction undertakings in history.

In one period of over 6,000,000 work hours, not a single disabling injury occurred. The safety record achieved at Savannah River was 36 times better than the national average for this type of work.

Of interest to refiners

Many safety problems, similar to those encountered in the oil industry, were solved on this project. "The Builders of Tomorrow" should prove stimulating to engineers, supervisors and others concerned with construction safety. For this reason, the Du Pont Petroleum Chemicals Division has obtained prints of the film. Any sales office will be glad to arrange showings.

Du Pont Lead Hazard Clinic helps promote safe TEL handling through education

Because the dangers inherent in the use of tetraethyl lead are of a serious nature, the Du Pont Company, as supplier of this compound, offers refiners a program to help maintain safe handling operations. Originated in 1951, the program is called the Du Pont Lead Hazard Clinic. A review in January, 1956, showed that Du Pont had presented the clinic 280 times for 44 oil companies before a total audience of 7,787 persons.

Refinery personnel whose work brings them into proximity with TEL learn about the Du Pont Lead-in-Air Analyzer. Slides and booklets help make the Du Pont Lead Hazard Clinic easy to understand.

The clinic is available to all refiners. It is suitable as a refresher course for refinery, marketing, pipeline and terminal supervisory personnel and as a supplement to your own training courses.

Your problems discussed

The six sections of the clinic program cover the toxic properties of TEL, the source of TEL tank cleaning and repair hazards, safe cleaning practices, demonstration of the Du Pont Petroleum Chemicals Division Lead-in-Air Analyzer, a question and answer period, and a summation.

A way of life

Called "Something Else Is Necessary," the summation is delivered by the Petroleum Chemicals Division Medical Director. It emphasizes to the individual his own responsibility in

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OVER

PETROLEUM CHEMICALS DIVISION
NEWS

CONTINUED **Hazard Clinic**

achieving safe TEL handling . . . in making safety "a way of life."

Experience has shown that the question and answer period offers one especially important benefit to your employees. It gives them a chance to get detailed answers to particular problems from men with extensive experience in every facet of TEL handling.

Visual aids

In easy-to-remember form, a slide presentation shows graphically the safe procedures and recommended precautions for tank entry work. This part of the clinic program is followed by a 5-minute demonstration of the Du Pont Lead-in-Air Analyzer.

A booklet, "Tank Talk," recaps the clinic and a copy is given to each member of the audience. Over 20,000 copies have been distributed and the booklet is now in its third printing.

Available to all

In the interest of sound preventive medicine and good industrial safety practice, Du Pont makes this clinic available to all oil companies. It is recommended for supervisory personnel currently concerned with TEL handling procedures, and to others who may in the future be assigned to this area of operation. To keep their programs up to date, some refiners have set up repeat clinics on an every-other-year basis.

If you would like further information about the Du Pont Lead Hazard Clinic, consult your local Du Pont Petroleum Chemicals Division representative.

HEADS PETROLEUM CHEMICALS DIVISION EASTERN REGIONAL LAB

Ed Jeffus joined the Du Pont Petroleum Chemicals Division in 1950 and was appointed Eastern Regional Laboratory Manager in January 1952. As manager, he works closely with refiners and provides technical services which are directed toward the more efficient utilization of petroleum additives.

Prior to joining Du Pont, Jeffus was a chemist at the Shell Oil Company's refinery at Norco, Louisiana.

His entry into the petroleum industry followed schooling at Magnolia A. & M., Magnolia, Arkansas, M. I. T., and ending with a B. S. in chemistry at the University of Arkansas in 1948. During World War II, he was a meteorologist in the U. S. A. F. and served a 25-month overseas tour in England and France.

Originally from Texarkana, Arkansas, Ed now lives in Wilmington, Delaware with his wife and two children. His hobbies include hunting, fishing, skeet and bridge.

EDISON D. JEFFUS

Mr. Jeffus is a member of the American Chemical Society.

"Speak to the Earth" in Third Edition

Appleton-Century-Crofts, Inc., publishers, have announced a new printing for "Speak to the Earth," a book about the oil industry. The writing of this book was commissioned by the Du Pont Company.

The initial printing was a de luxe edition which was exclusively distributed by the Du Pont Petroleum Chemicals Division. At the same time, a standard edition was produced and marketed to the public by the publisher. This has been sold out.

Of the edition now in printing, 1500 copies will be used by the O.I.I.C. The remainder will be available through regular book stores.

Written by Max Miller, "Speak to the Earth," was first introduced in June, 1955.

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FIG. 11. Rear view of console showing wiring duct on control house wall.

FIG. 12. Interconnecting wiring duct between unit and control house.

controller in case of failure in either, and separate circuit protection is provided for the manual control and power relay. This permits the valve to be operated manually from the control house in case of failure in either the transmitter, recorder, or controller. It is also possible to have a record of the controller variable while on by-pass in case of failure in the power relay.

Accessible from the rear of the console are individual mercury type control power switches for each recorder and its transmitter, each controller and its recorder and transmitter, and each manual controller. The mercury switches have one disadvantage—if the console is accidentally jarred, the mercury contact is momentarily broken. This brief interruption of power does not upset the control action, but it does produce "pips" on the recording charts.

Emergency Instrument Power System. Although the plant is not designed to operate in cases of complete electrical power failure, it was considered necessary to provide the instruments with emergency power to protect against an abrupt loss of control. Rather exacting emergency power requirements were imposed by the instrument manufacturer to insure continuous operation of the instruments at their guaranteed accuracy.

These requirements were:

2) A maximum of three-second interruptions.
2) Supply to have a plus or minus 3-cycle per second frequency regulation. (The voltage regulation was not critical, since power is fed through a constant voltage transformer.)

An existing emergency power system supplied by a 20-kw steam turbine was available in a nearby process unit. Tests indicated this turbine generator required five to ten seconds to come from rest and deliver rated voltage. To meet the three-second requirement, it was necessary to install a special emergency system for instrument and control power. This auxiliary unit is continuously operating and capable of delivering power immediately when called upon. The installation consists of an a-c motor, an a-c generator, a d-c unit (motor or generator), all on the same shaft, a storage battery, and a control cabinet. The unit rotates continuously. Normally the a-c motor drives the generator and the d-c unit, which acts as a generator to maintain the battery in a fully charged condition. If power fails, the battery supplies power to the d-c unit, which acts as a motor to drive the a-c generator.

The battery will supply the load of the console for about a half hour. To conserve the battery and to permit emergency operation for longer than one-half hour, the instrument system load is transferred to the previously-mentioned 20-kw turbine generator as soon as it is up to rated speed and voltage.

Experience indicates that the emergency power requirements imposed were more exacting than necessary for this plant. These requirements may be justified for continuous operation at the guaranteed accuracy; however, since the purpose of this plant's emergency system is only to bring the unit to a gradual shut-down, extreme accuracy is not required. Field tests, plus an unexpected complete power failure, indicate that instrument power may be off for up to ten seconds and still maintain satisfactory control for making an orderly shutdown of the unit.

Interconnecting Wire. A single metal cableway carries all wiring between console, transmitters, thermocouples, and power relays. It is mounted on pipe supports and is "T" shaped in its layout. One leg runs the entire length of the plant, and from it another leg is sent through the reactor-furnace section. A photograph of the cableway from the unit to the control house is shown in Fig. 12. This type of construction was chosen over conduit for its initial economy of material and labor and its future flexibility. Most

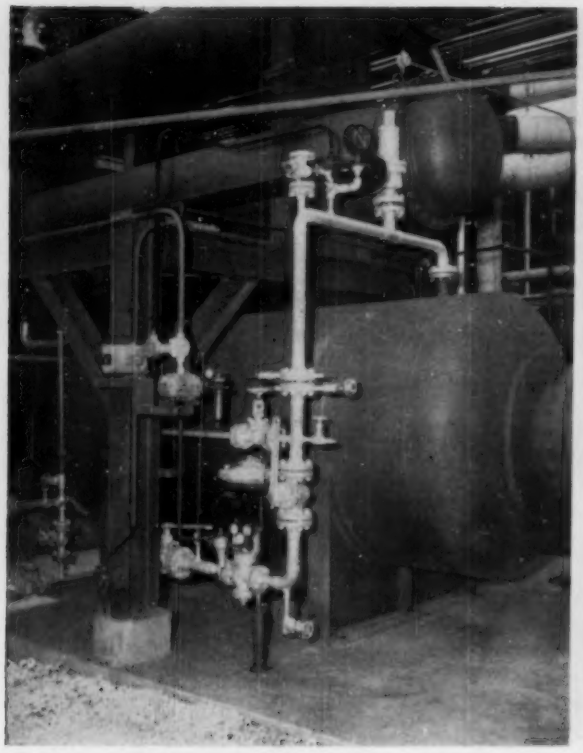

FIG. 13. Typical remote installation showing transmitter power relay and diaphragm-operated control valve.

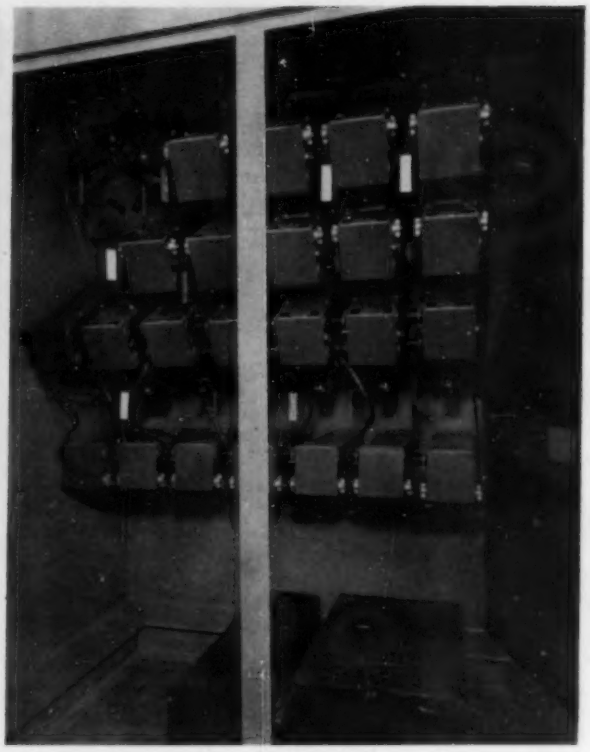

FIG. 14. Interconnecting wiring behind console.

processes undergo expansion and refinements over the years, and the instrumentation must keep pace. The cableway system greatly simplifies the problem of relocating or adding instruments. Except for the control house, which has special cableway, the cableway has a cross-section of 4 by 6 in. It is made of 16-gage hot, dipped galvanized iron. Its U-shaped channel lid is fastened to the duct with sheet metal screws and sealed with a Neoprene gasket. Branch connections from the cableway system to the field transmitters, power relays, and thermocouples are made with rigid steel conduit. A seal fitting is provided in all conduits at the end away from the duct. A typical installation is shown in Fig. 13.

All wiring consists of multiconductor cables. Except for thermocouple leads, the insulation and jackets are of the thermoplastic type. The transmitters use a special four-conductor cable made up of two shielded No. 22 AWG stranded and twisted wires for the signal leads and two unshielded No. 20 AWG stranded and twisted wires for the power to the transmitter. The power relay cables are made up of two unshielded stranded No. 20 wires. This wiring is adequate for installations up to 1000 ft in length. Thermocouple leads are iron-constantan, No. 16 AWG, with thermoplastic insulation, and cabled in pairs with a cotton lacquer jacket and a metal braid over-all. Instead of providing spare conductors in each cable, several spare cables of each of the above types were included in the original installation. These spare cables extend the full length of the duct system and thus may be picked up at any point desired.

Transmitters and Power Relays. The transmitters and power relays have explosion-proof enclosures approved for Class I, Group D, Division 1 locations. There is little difference between the installation of this type of equipment and pneumatic equipment. The transmitter should be mounted as close as possible to the measuring take-off point for accuracy and rapid response, yet mounted at convenient height for maintenance and calibration. The pressure and differential pressure transmitters can be calibrated by hanging dead weights from a point at the rear of the transmitter lever assembly. See Fig. 15. To take advantage of this feature, the transmitter must be mounted upright and with no obstruction at least 18 in. below it. Transmitters are equipped with their own dampening device, which permits the transmitter to be mounted in areas of normal vibration generally found in refinery work without special precautions. In locations subject to unusual vibration, it has been found necessary to provide separate and more rigid mounting, rubber vibration absorbers between the mounting bracket and the transmitter, and a section of flexible hose in the metering lines. Power relays are not equipped with any internal dampening and are rigidly mounted.

As mentioned above, this plant has 15 flow transmitters, all of which are the DP type with teflon diaphragms. Teflon was selected over steel because of its superior corrosion resistance and characteristic minimum zero drift. The diaphragms for the pressure transmitters are stainless steel.

The primary element for a temperature recorder or controlling system may be any thermocouple or resistance element. This installation employs iron-constantan thermocouples, with a thermocouple-converter located in the console. The thermocouple-converter is designed to convert the thermocouple d-c millivoltage to the base 0-0.5 v, 60-cycle a-c/signal to feed other instruments in the system. The thermocouple-converter has both adjustable zero suppression and adjustable range. The field-mounted primary elements as installed here have one shortcoming—they are blind transmitters; that is, they do not provide a local indication of the measured variable. This problem has

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since been overcome and an instrument for a local reading is now available.

Operation

Start-Up. The performance of the instrument installation during start-up and subsequent operation has exceeded expectations. As with all new developments, a period of finding and eliminating the "bugs" was anticipated, but in this case the "bugs" never materialized. The start-up of the plant was completely free of instrument problems. Operations to date have been characterized by the same performance and it is apparent that there are no problems peculiar to this electronic system.

Adjustment and Calibration. During start-up, the optimum settings for proportional band, automatic reset, and rate action were found by the usual "cut and try" procedure. The standard controller has a range of 2 to 200 per cent proportional band, .03 to 20 repeats per minute automatic reset action, and .05 to 8 minutes rate action. Standard controllers are used for the three temperature controls, while flow and pressure controllers have standard proportional band with a fast acting automatic reset action (.03 to 240 repeats per minute), but no rate action. The adjustments made during start-up clearly indicate that faster rate times are possible with the electronic system than with a pneumatic system. Although direct comparisons were not made, it is estimated, based on past experience, that rate times used in this installation are 50 per cent faster than for a pneumatic system. The faster rate times make it possible to hold the controlled variable within a closer tolerance to the set point. Optimum settings for proportional band and automatic reset action were found to be comparable to similar settings for a typical pneumatic system.

Equipment Problems. The few difficulties that have been experienced have been of a type common to instruments in general. For example, several chart drive motors have failed, but the "plug-in" feature of the instruments greatly simplifies this problem in that a spare recorder can be placed in service and the faulty instrument repaired more conveniently and quickly in the instrument shop. There are also several instances of zero drift in the flow transmitters D/P cells, which fault is common to most D/P cells and corrected by the usual "working in" technique. Repeated failure of a flow transmitter metering the recycle gas on the discharge header of four compressors oc-

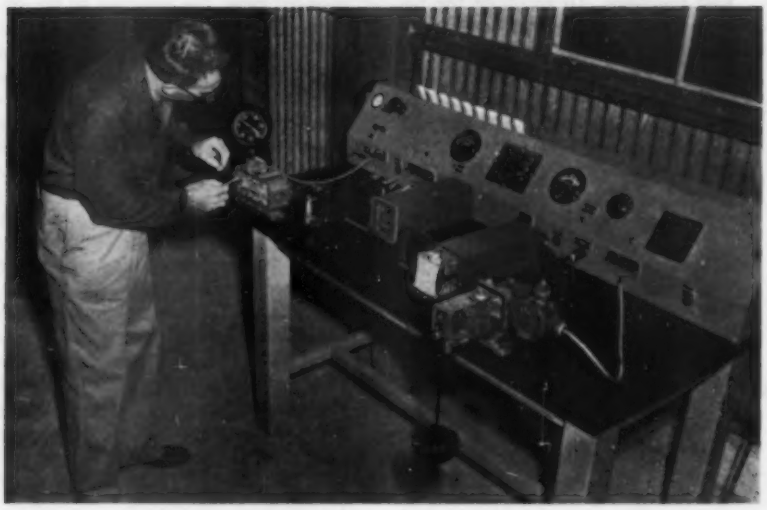

FIG. 15. Test bench for maintenance and calibration of units in control system.

curred. This transmitter was subjected to two unfavorable conditions: One, considerable vibration which existed at its mounting and throughout the compressor house; two, the pulsating flow of the gas being measured. Providing a rubber cushion between the transmitter and its mounting bracket and inserting sections of flexible metal hose in both metering lines relieved the vibration condition. Failures continued, and the problem was found to be more pulsation than vibration, however. The use of pulsation dampeners and a heavier assembly for the transmitter supplied by the instrument manufacturer solved the problem.

Operating Advantages. Speed of response of the instruments is definitely faster as compared to similarly installed pneumatic types. Because of the limitations of pneumatic control valves, however, it has not been possible to take full advantage of this feature. There is considerable concentration of engineering effort underway to remove this obstacle, and undoubtedly more suitable control valves will be available soon.

The accuracy of the electronic measuring recording system is one-half of one per cent. Unstable calibration has always been a problem with older types of instruments. The inherent stability of electronic instruments makes it possible to maintain accurate calibration for indefinite periods of time, however. Another operational advantage of this type of equipment is the fact that the recorder pen is completely dissociated from the controlling action. Thus accidental deflection of the pen during inking operations, etc., does not affect control action. A very significant accomplishment is the fact that the entire Catformer is being operated by two men per shift. The electronic instrument system is not primarily responsible for this. It is certain that the ease and dependability of operation of the controls, however, together with the fact that the console arrangement makes all controls and instruments readily accessible and visible to a single operator, has been a factor. Of course, console construction is possible as a result of miniaturization, which is not exclusive to electronic instruments, but electric wiring lends itself more readily to console construction than does pneumatic tubing. See Fig. 14.

Maintenance

Training Program. It is intended that plant personnel handle the maintenance of this equipment, and no difficulty has been experienced in carrying out this plan. The maintenance of electronic equipment is not completely foreign to the average instrument department in that electronic equipment in the form of temperature recorders has been in wide use in the process control field for many years. In particular, this equipment employs time-proven electronic circuits and components. The number of tubes, the circuit arrangements, and the components are, in fact, less complicated than the familiar home radio. Because of the scope of this project and the many details of a new system, however, a definite maintenance program was set up. The plan carried out was to have an Atlantic Refining Company engineer visit the instrument manufacturer for one week to be given extensive instructions. The engineer then conducted a training program at Atreco in the operation and maintenance of the installation. Training was given to both operating and maintenance personnel.

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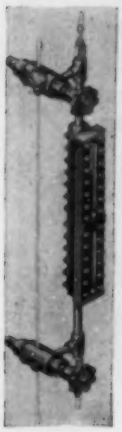

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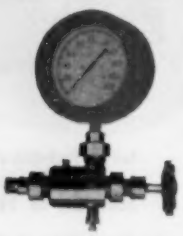

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Test Facilities. To facilitate the instruction at the refinery and to simplify maintenance, a special test set-up was made. See Fig. 15. The set-up is built around a portable Swartwout test unit that supplies simulated transmitter and set point signals and which is so mounted in the panel to be easily removed for field checks. The bench also incorporates an adjustable voltage supply, an adjustable and regulated air supply, a voltmeter reading supply voltage, and a milliameter for controller output current. A vacuum tube voltmeter is used to read check point voltage when the set-up is used for maintenance work. This set-up makes it possible to assemble a complete control loop for system calibration and to serve as a demonstrator for class instruction. It also provides convenient outlets for test and calibration of the individual units of the system. The cost of material for this set-up was approximately $250, which can easily be justified by the time saved over repeated make-shift test set-ups and the consistent and accurate calibrations which are possible.

Maintenance Procedures. The practice followed in maintaining this equipment is to repair field-mounted units, such as transmitters and power relays, on the spot if possible. Console-mounted instruments, being of the "plug-in" type, are returned to the instrument shop, where they can be maintained more efficiently. It is comparatively easy to isolate a system failure to a particular unit, i.e., recorder, controller, etc. If the faulty unit cannot be conveniently or quickly repaired on the site, it is replaced with a spare instrument. The faulty unit is then set up on the test bench, and through a system of check point voltages, the trouble may be isolated to a particular section or component. Once the trouble is located, the unit is repaired and recalibrated and then placed in stock as a spare. Consistent and stable calibration and the ability accurately to preset control functions permit random interchange of units of the system. In addition, the ability accurately to preset control functions makes it unnecessary to go through a cumbersome "in service" cut-try adjustment procedure when interchanging controllers.

Maintenance Experience. No unusual maintenance problems have been experienced; however, the installation has not been in service long enough to clearly establish maintenance requirements. It will be recalled that one of the factors influencing the decision to make this installation was the fact that maintenance requirements would be reduced and simplified. So far, the indications are that this expectation may be realized. The ready interchangeability of equipment, the test and calibration bench, and the standardized procedures established already have demonstrated that normal maintenance can be accomplished with minimum disruption of the process.

There have been no tube failures to date. A program of tube replacements at regular intervals has not been established but will be considered when sufficient data on tube failures are accumulated. It is interesting to note that industrial long-life tubes are used for the controllers, while standard tubes are used for the recorders. As a recorder can be removed for repairs or tube replacement without disturbing control action, the use of industrial tubes costing approximately five times as much as standard tubes appeared uneconomic.

A complete stock of all necessary component parts for all anticipated maintenance has been established. In addition, complete spare recorders, controllers, transmitters, power relays, etc., are stocked on the basis of one spare unit for every ten units in service with a minimum of one spare unit of each type. Based on operations to date, it appears that the number of spare units could be safely decreased.

Conclusion

The obvious questions to ask after

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FIG. 21—Lip Mold

FIG. 22—Standard

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venturing into a new field such as this are:

(1) Have the objectives been accomplished?

(2) From the experience gained, what changes will be made in future installations?

The answer to the first question is a definite "yes." The start-up was made without delay due to instrument failures and subsequent operation has been continuous and dependable. There have been no troubles peculiar to electronic systems, and while it is too early to draw conclusions regarding maintenance, it is clear that the electronic instruments can be maintained easily and without disruption of plant operation.

The plant is operating with two men per shift and improvement in control action has been realized. Savings in first cost have not materialized to the extent originally estimated, largely as a result of expenditures on an emergency power system that experience has shown were unnecessary. A valuable and reliable amount of experience in all phases of electronic instrumentation has been acquired which will be exploited in future installations.

Although this first installation has been more than satisfactory, some improvements will be made in future installations on the basis of the experience to date. For example:

(1) Future similar installations will not include such an elaborate emergency power system.

(2) The field transmitters will have indications near the control valve.

(3) Electric or hydraulic control valves, if suitable ones are available, will be used where speed of response is significant.

(4) Further simplifications and economies in interconnecting wiring will be adopted.

(5) The absence of winterizing problems in cold climates will be exploited.

(6) Initial stocks of spare instruments and parts will be reduced.

In conclusion, this plant has shown that electronic process control is here to stay, and there seems little doubt that the future trend is going to be strongly in this direction. ★ ★ ★

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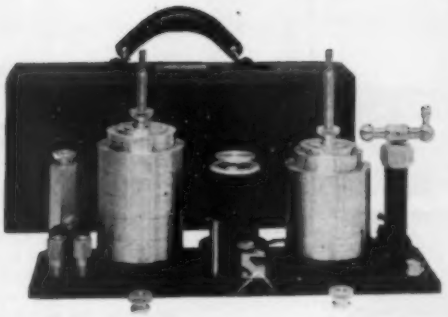

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1929	33,036,490	16,518
1930	30,867,752	15,433
1931	34,179,000	17,089
1932	29,039,000	14,519
1933	45,200,202	22,600
1934	56,059,489	28,029
1935	95,133,284	47,566
1936	132,912,821	66,456
1937	163,030,410	81,515
1938	130,358,652	65,179
1939	213,027,548	106,513
1940	276,814,363	138,407
1941	428,325,692	214,162
1942	426,731,106	213,365
1943	653,332,000	326,666
1944	784,137,000	392,068
1945	818,020,000	409,010
1946	994,277,000	497,138
1947	1,251,699,000	625,849
1948	1,480,876,000	740,438
1949	1,491,111,000	745,555
1950	2,150,518,000	1,075,259
1951	2,431,408,000	1,215,704
1952	2,333,924,000	1,166,962
1953	2,776,627,000	1,388,313
1954	2,827,803,000	1,413,901
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*1956	4,000,000,000	2,000,000

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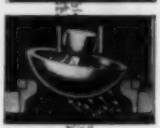

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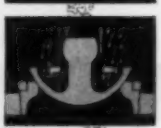

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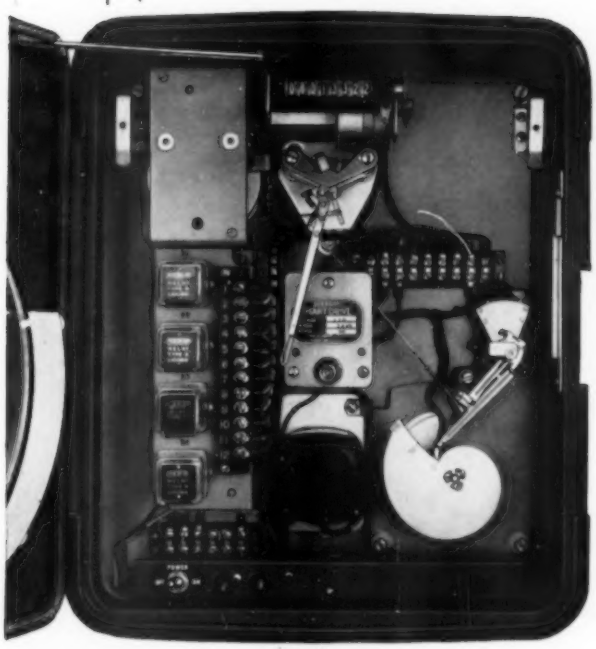

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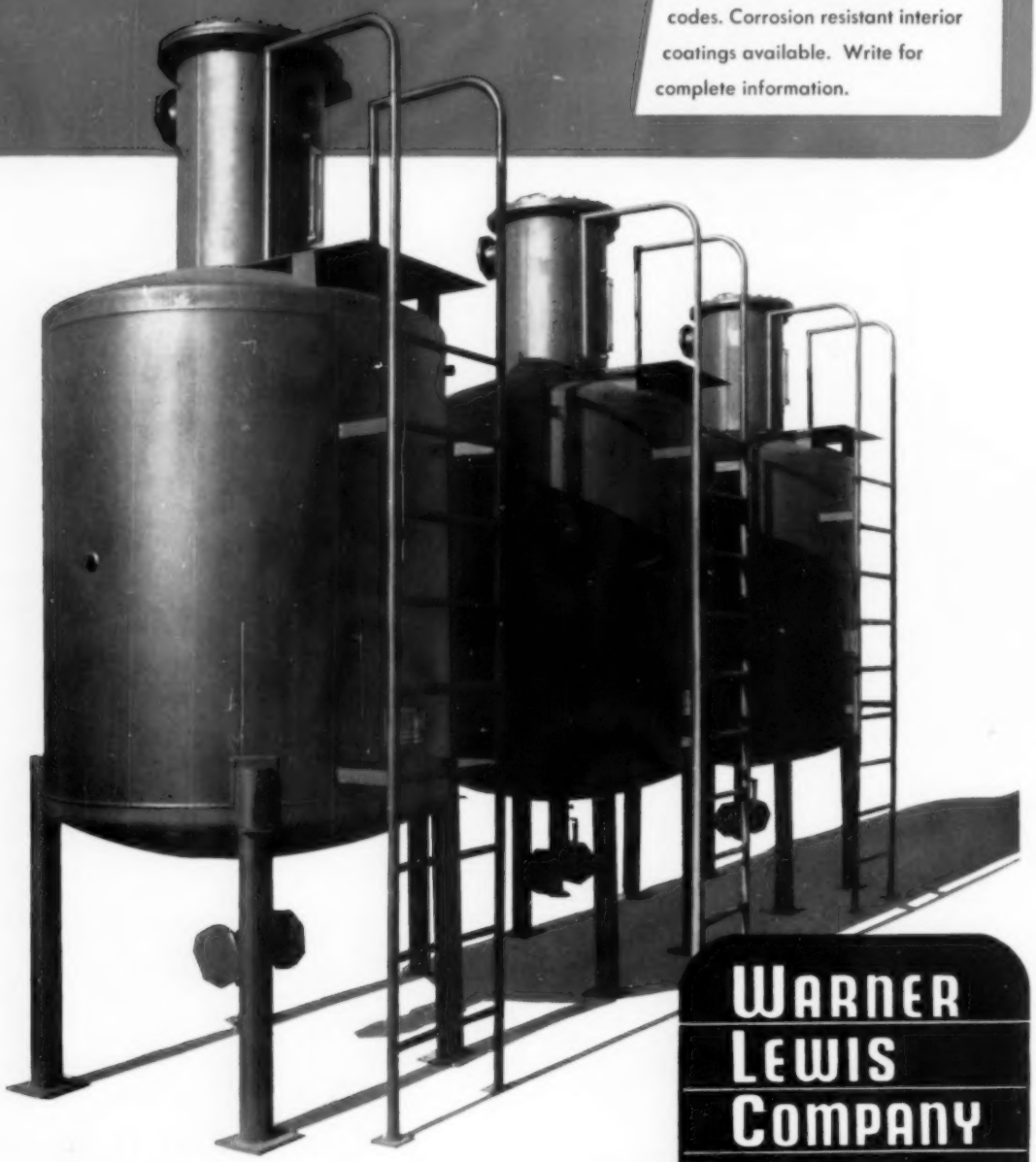


WARNER LEWIS COMPANY

BOX 3096 • TULSA, OKLAHOMA

DIVISION OF FRAM CORPORATION

PIPE LINE DEVELOPMENTS ★ ★ ★

Roundup of Current Planned and Proposed Construction

The following tables list the company, mileage, pipe size, and location of proposed pipe line projects — crude, products, and natural gas — reported to The Petroleum Engineer. Company addresses are given where furnished or known.

CRUDE LINES

Name of Company	Miles	Size	Location
Ar-Mex Pipeline Company, Dallas, Texas	790	12-14	Guernsey, Wyoming to Coolidge, Arizona
Big Horn Pipe Line Company, Cheyenne, Wyoming	150	8	Ash Creek field to Service Pipe Line Company connection
Kaybee Pipe Line Company, Muskegon, Michigan	46	10	Griffith, Indiana to New Buffalo, Michigan
Mishi, Inc., Detroit, Michigan	222	10	Highland Indiana to Alma, Michigan
National Co-Operative Refinery Association, Kansas City, Missouri	30	8	Lyons to Mc Pherson, Kansas
Offshore Gathering Company, Houston, Texas	364	20	Offshore line in Gulf of Mexico from Sabine Pass to Mississippi River.
Powder River Pipe Line Company, Casper Wyoming	436	10-16	Williston Basin to Laurel-Billings, Montana, refining area
Richfield Oil Corporation, Los Angeles, California	4	10	Lines in Los Angeles area
Shell Oil Company, New Orleans, Louisiana	25	—	Gathering lines (oil and gas) for Block 24 and Block 27 fields off Plaquemines Parish to onshore compressor station and central storage near Southwest Pass, Block 24
Sinclair Pipe Line Company, Independence, Kansas	150	20	Mexia to Houston, Texas. Replacement of existing line.
Stanmount Pipe Line Company	140	10	Beaver Lake field, North Dakota to Cromer, Manitoba station on Interprovincial Pipe Line
Trans-Border Pipe Line Company	110	—	Skagway, Alaska to Whitehorse, Yukon, Territory
Trans-Prairie Pipe Lines, Ltd., Winnipeg, Manitoba	17	3-6	Lines in Cromer and Virden areas, Manitoba
Union Oil Company, Los Angeles, California	815	—	Considering line from shale oil plant at Rifle, Colorado, to Los Angeles area
U. S. Department of Defense	97	—	Crude line from Elk Hills Naval Reserve to Los Angeles

PRODUCTS LINES

Name of Company	Miles	Size	Location
Ar-Mex Pipe Line Company, Dallas, Texas	60 70	8 8	Coolidge to Phoenix, Arizona Coolidge to Tuscon, Arizona
Bell Oil and Gas Company, Tulsa, Oklahoma	140	6-8	Ardmore to Cushing, Oklahoma
California-Oregon Pipe Line System, Crescent City, California	103	6	Crescent City, California to Medford, Oregon
Cosden Petroleum Corporation, Big Spring, Texas	100	6	Big Spring, to Abilene, Texas
Deep Rock Gas Company (LPG Line)	120	6	Tioga, North Dakota to U.S.-Canadian Border
El Paso Natural Gas Company, El Paso, Texas (LPG Line)	60	10	Farmington to Gallup, New Mexico
International Pipe Line, Inc., Minneapolis, Minnesota	132	8	Wrenshall to Minneapolis, Minnesota
Magnolia Pipe Line Company, Dallas, Texas (LPG Line)	214	8	Midland to DeLeon, Texas (Converting existing crude line)
Maloo Pipe Line, Inc., Roswell, New Mexico	91 138	6 6	Prewitt to Albuquerque, New Mexico Artesia to Newman, New Mexico
Mayflower Pipe Line Company	400	10	New Jersey refineries to New England points
Moore-Stonar Company	200	6	Glendive, Montana to Minot, North Dakota
Phillips Pipe Line Company, Bartlesville, Oklahoma	50	12	From Sweeny to Pasadena, Texas, refinery, near Houston.
Plantation Pipe Line Co.	327	18	Baton Rouge, La., to Helena, Ala.
Sioux Oil Company	50	6	Newcastle, Wyoming to Rapid City, South Dakota
Standard Oil Company (Ohio) c/o Sohio Pipe Line Company, St. Louis, Missouri	35.5	6	Mogadore to Girad, Ohio
Sun Pipe Line Co., Philadelphia, Pennsylvania	110	14	Marcus Hook, Pennsylvania to Newark, New Jersey
Texas Eastern Transmission Corporation, Shreveport, Louisiana	1168	16-20	Plans to convert the "Little Inch" line between Beaumont, Texas and Moundsville, West Virginia upon completion of new gas facilities. Has FPC approval to abandon gas service from the "Little Inch."
Winnipeg & Central Gas Company, Winnipeg, Manitoba (LPG Line)	210	6	U.S.-Canadian border to Winnipeg (See also Deep Rock Gas Company listing)

There's **MORE** Cooling Surface in these deep-ribbed **MOTORS**

No Day is FRYDAY

with these Allis-Chalmers MOTORS

● Frying of insulation is impossible under normal conditions with the extra-large cooling surface of Allis-Chalmers rib-type TEFC motors. The result—you expect and get longer motor life.

The engineered partner of A-C motors is Allis-Chalmers control.

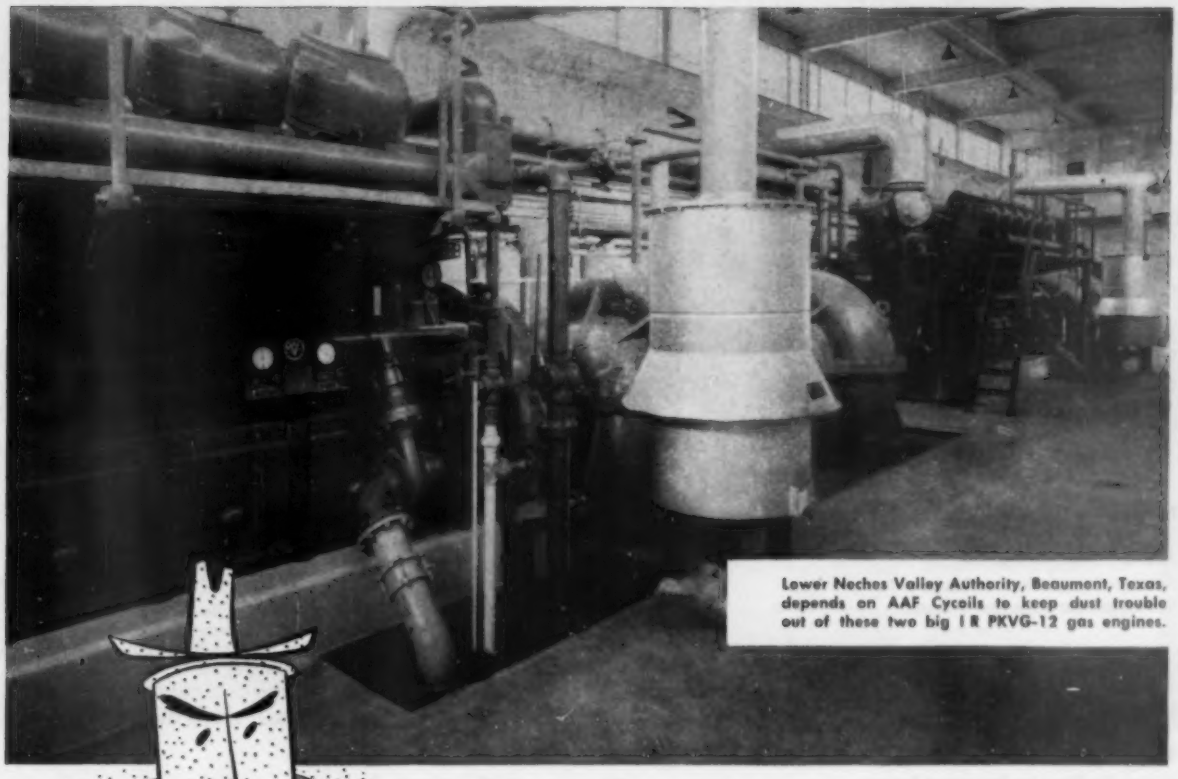
Get Complete Information

As a new machinery component or as replacement, specify Allis-Chalmers. Discuss your particular application with your nearby A-C distributor, A-C district office, or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.

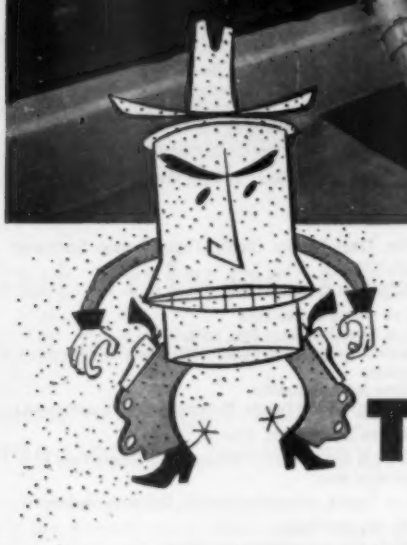
ALLIS-CHALMERS

A-C ALLIS-CHALMERS

A-4853



Lower Neches Valley Authority, Beaumont, Texas, depends on AAF Cycoils to keep dust trouble out of these two big I R PKVG-12 gas engines.



CYCOILS Corral Tough Texas Dust

THESE two gas engines each drive two pumps in tandem, with capacity of 110,000 gpm per unit, for the Lower Neches Valley Authority, Beaumont, Texas. It's a big job. There's no time for down-time.

That's why you see those AAF Cycoil heavy-duty oil bath air cleaners on the job. They provide 4-way cleaning—impingement, scrubbing, cyclonic action and filtering. Over 90% of the fine dust content in the air is trapped in oil and removed by centrifugal action before most of it even reaches the filter pads! Additional action of filtering pads, what's more, plus positive oil circulation for self-cleaning action, provides air that's virtually 100% *dust-free.*

Only Cycoil gives engines and compressors this kind of protection. Write for Bulletin No. 130 . . . the nuts-and-bolts, facts-and-figures story on Cycoil Oil Bath Air Filter!

Type CMS Multi-Duty Filters

Type G Pipeline Air Filters

American Air Filter
COMPANY, INC.
384 Central Avenue, Louisville 8, Kentucky
American Air Filter of Canada, Ltd., Montreal, P. Q.

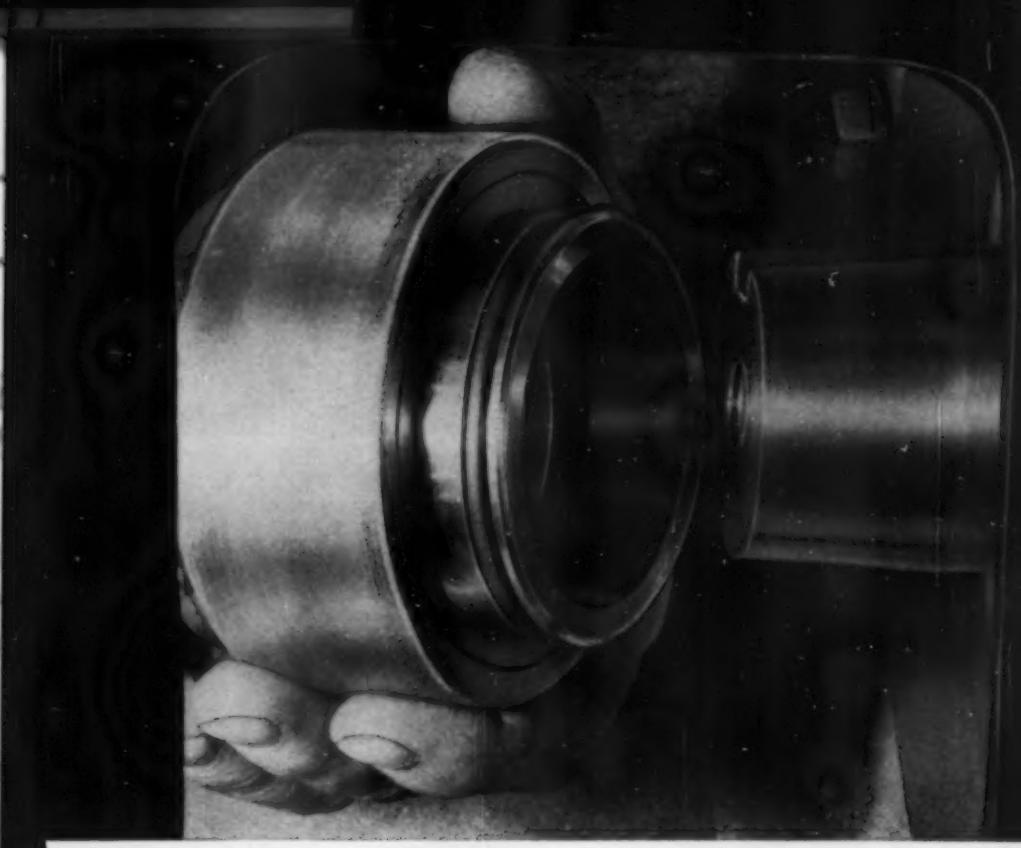
BETTER AIR IS OUR BUSINESS

Type OCH Intake Air Filters

Cycoil Oil Bath Air Filters

GAS LINES

Name of Company	Miles	Size	Location
Alberta Gas Trunkline, Calgary, Alberta	315	6–34	Gas gathering system in Alberta fields to serve proposed Trans Canada Pipe Lines
American Louisiana Pipe Line Company, Detroit, Michigan	117	22	Defiance, Ohio, to Bridgman, Michigan
Carolina Natural Gas Corporation	185	2–12	Lines in North and South Carolinas
Central Hudson Gas & Electric Corporation, Albany, New York	48	12	Albany to Kingston, New York
Central Kentucky Natural Gas Company, Charleston, West Virginia	21.1	20–24	New lines in Kentucky
Coastal Transmission Corporation, Dallas, Texas	550	30	McAllen, Texas to Baton Rouge, Louisiana
Colorado Interstate Gas Company, Colorado Springs, Colorado	110	6–8	Julesburg area to Denver, Colorado
El Paso Natural Gas Company, El Paso, Texas	413	34	Farmington, New Mexico to Topock, Arizona
Houston Texas Gas & Oil Company, Houston, Texas	961	12–20	Baton Rouge, Louisiana to Miami, Florida, serving Florida area with various laterals
Iron Ranges Natrual Gas Company, St. Paul, Minnesota	115	—	New system, to include 47 miles of laterals to towns in Mesabi Iron Range connecting Midwestern Gas Transmission's proposed line near Aurora, Minnesota
Lone Star Gas Company, Dallas, Texas	230	30	Cotton County, Oklahoma to Fritch, Texas
	205	24	Snyder, Texas to Cotton-Fritch line
Michigan-Wisconsin Pipe Line, Detroit, Michigan	252	4–24	Loops on system in Missouri, Iowa, Illinois, and Wisconsin
Michigan-Consolidated Gas Company, Detroit, Michigan	25	12	Sparta to Muskegon, Michigan
Midwestern Gas Transmission Company, Houston, Texas	1112	12–24	Main line from US-Canadian Border near Emerson, Manitoba-Noyes, Minnesota to Portland, Tennessee
	648	3–18	Laterals off main line to serve communities in Minnesota, North Dakota, and Wisconsin
Mid-Western Industrial Pipelines, Ltd, Edmonton, Alberta	30	10	Alexander field near Edmonton to Pembina field
Montana-Dakota Utilities Company, Minneapolis, Minnesota	41.8	12	Tioga-Beaver Lodge field in North Dakota to main transmission line
Morganfield Natural Gas Company	31	4–6	New lines in Kentucky
Natural Gas Pipe Line Company of America, Chicago, Illinois	350	20–26	Amarillo, Texas to Wise County, Texas, through Southwest Oklahoma
Nevada Natural Gas Company, Las Vegas, Nevada	114	10	Loop of present system
Northern Natural Gas Company, Omaha, Nebraska	15	24	Loops on system in Nebraska
	28	24	Ogden to Redfield storage area, Iowa
	168	20	St. Paul-Minneapolis to Duluth, Minnesota and Superior, Wisconsin
	163	10–12	Main lines in South Dakota
	307	Var.	Branch lines in South Dakota, Minnseota, Iowa, and Wisconsin
Northwest Utilities, Ltd.	42	—	Bonnie Glen to Edmonton, Alberta
Offshore Gathering Company, Houston, Texas	364	30	Offshore gas line in Gulf of Mexico from Sabine Pass to Mississippi River.
Pacific Gas & Electric, San Francisco, California	150	34	Loops on Topock, Arizona to Milpitas, California, system
Panhandle Eastern Pipe Line Company, Kansas City, Missourie	20	24	Rolla to Hugoton, Kansas
	74	4–16	Loop lines and replacements on system
Phillips Petroleum Company, Bartlesville, Oklahoma	22	20	From Qyinduno field, Roberts County to Rock Creek, Texas, gasoline plant.
Pioneer Natural Gas Company, Amarillo, Texas	261	3–22	New lines, loops, replacements and irrigation feeder lines Panhandle and South Plains of Texas
Pine Tree Natural Gas Company	204	—	Boston, Massachusetts to Bangor, Maine
Shenandoah Gas Company, Winchester, Virginia	39	3–8	Middleton, Virginia to Martinsburg, West Virginia
Southern Counties-Southern California Gas Companies, Los Angles, California	236	30	Topock, Arizona to Newhall, California.
Southern Natural Gas Company, Birmingham, Alabama	39	—	Loops on system
Tennessee Gas Transmission Company, Houston, Texas	221	26–30	Loops in Ohio and Kentucky
	100	—	New gathering lines in Texas and Louisiana
	162	—	Loops in Kentucky, Ohio, and Pennsylvania
	335	6–24	Gathering system in South Louisiana
Texas Eastern Transmission Corporation, Shreveport Louisiana	422	30	McAllen to Vidor, Texas
	530	30	Loops on system from Texas to New Jersey
	180	Var.	Supply, lateral, and gathering lines
Texas Gas Transmission Corporation, Owensboro, Kentucky	105	10–12	Eunice to Morgan City, Louisiana
	81	8–30	Loops on system
Trans Canada Pipe Lines, Ltd., Calgary, Alberta	2247	14–34	Alberta area to Toronto, Montreal, and other eastern Canada areas
Union Gas Company of Canada	180	—	Dawn Storage Field to Hamilton, Ontario
United Natural Gas Company	50	12	Elk county to Jefferson county, Pennsylvania
Utah Natural Gas Company, Salt Lake City, Utah	40	16	Orem to Salt Lake City, Utah
Virginia Natural Gas Company	153	—	Buckingham to Richmond and Portsmouth, Virginia



CARTRIDGE SEAL slides off mixer shaft, which uncouples to permit removal. New cartridge goes in its place. Taper on shaft insures correct alignment when recoupling.

Cut mixer maintenance 60%

with this cartridge-type *rotary seal*

Stops leakage! Runs years without adjusting! Slides off for fast, easy replacement!

If you're mixing or blending in big tanks, here's the newest way to slash mechanical mixer upkeep as much as 60%.

For here at last is a rotary mechanical seal—optional on new LIGHTNIN Side Entering Mixers—that stops leakage around the tank, ends stuffing-box repacking and adjusting for good.

And for the first time ever on big-tank mixers, you can replace this seal in a jiffy if you ever have to! No need to dismantle or remove the mixer from the tank. No need to drain the tank. No special skill required!

Even under a full head of liquid in the tank, the seal-change job is so simple it takes only minutes. The mixer shaft retracts to seal the tank, then uncouples. The seal cartridge slides off in one piece. A new cartridge slides on; the mixer shaft automatically realigns itself when recoupled—and you're back in operation.

The LIGHTNIN seal cartridge is a complete unit assembly, easy to stock as a replacement, or quickly obtainable in all sizes and materials, for the simplest or most difficult operating conditions.

Already, many oil companies are using LIGHTNIN Seals—and saving many thousands of dollars per year. Your LIGHTNIN Mixer representative can give you the full story—show you how much *you* can save. Call him today—he's listed in your copy of Refinery Catalog. Or get the facts by mail: send the coupon for 8-page, fully illustrated bulletin.

"Lightnin® Mixers"

MIXCO fluid mixing specialists

Left: **NO STUFFING BOX** to repack or adjust. No leakage around the tank. When correctly applied, seal runs for years without adjustment. *Right:* **REPLACEMENT** is simple, even with tank full. Mixer shutoff closes like a valve to keep liquid in the tank while seal is being changed.

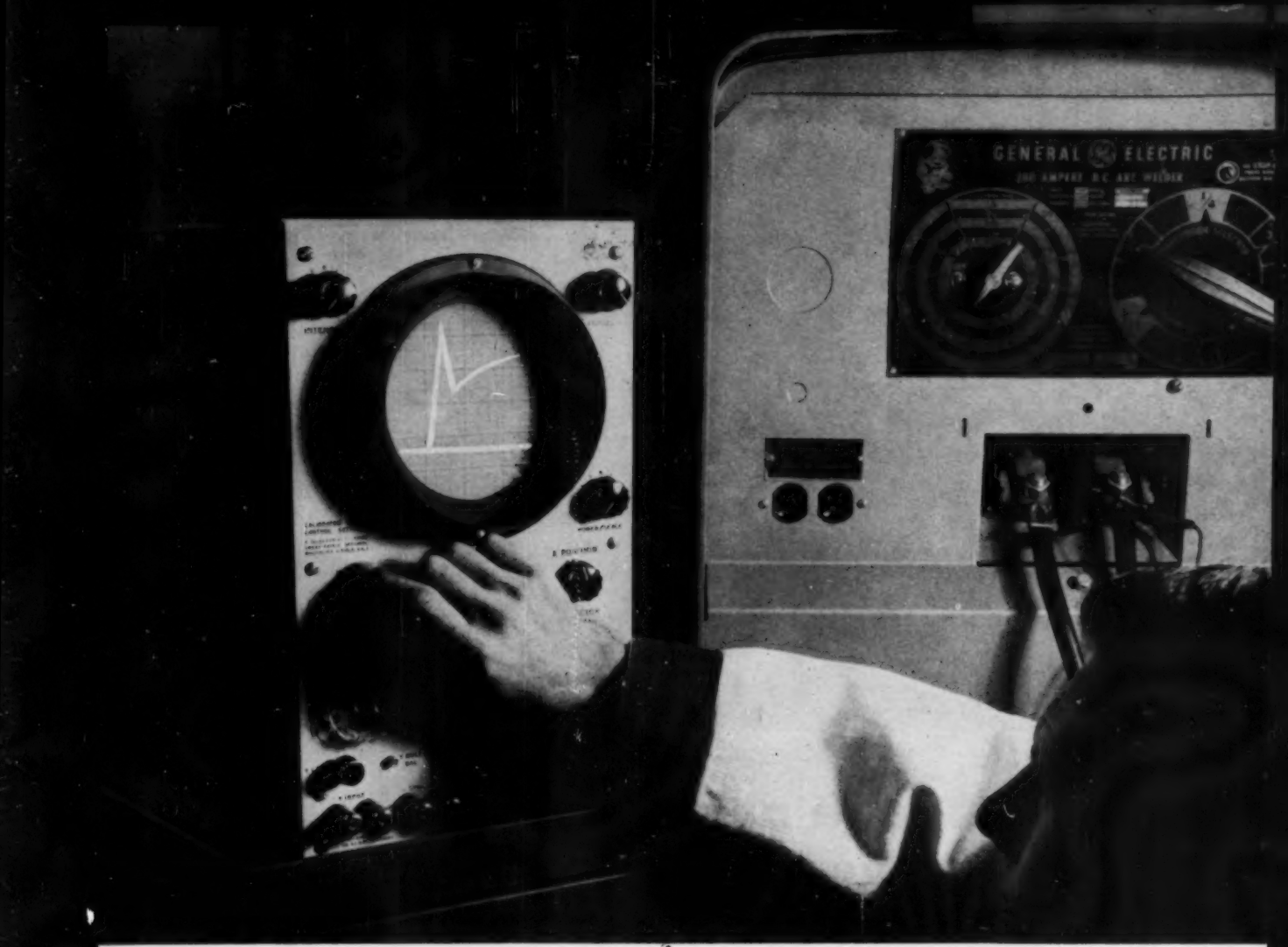
☐ *Quick!* **Send us the cost-cutting facts on LIGHTNIN Rotary Mechanical Seals—Bulletin B-111. We'd also like catalog information on these LIGHTNIN Mixers:**

- ☐ B-102 Top or bottom entering; turbine, paddle, and propeller types: 1 to 500 HP
- ☐ B-103 Top entering propeller types: ¼ to 3 HP
- ☐ B-104 Side entering: 1 to 25 HP
- ☐ B-108 Portable: ⅓ to 3 HP
- ☐ B-112 Laboratory and small-batch production types
- ☐ B-110 Condensed catalog showing all types
- ☐ B-107 Data sheet for figuring mixer requirements

Check, clip, and mail with your name, title, company address to:

MIXING EQUIPMENT CO., Inc., 127-b Mt. Read Blvd., Rochester 11, N.Y.

In Canada: Greey Mixing Equipment, Ltd., Toronto 10, Ont.



G.E.'S NEW ENGINE-DRIVE WELDER GIVES YOU . . .

Steady Welding Output—at Full Load; Improves Weld Quality, Costs Less Too

If you're using more than a 200-amp engine-drive welder for light to medium-heavy construction, you may be losing money. You may be paying for inefficiency—compensating for excessive loss of amperage and arc heat when operating at full load for sustained periods.

Now, with G.E.'s new 200-amp engine-drive welder, it's not necessary to buy more expensive, higher rated machines for pipeline, light construction, or job-shop work. This field-tested welder gives you steady output and 100% arc stability, hour-after-hour, even when operated ***above*** full load.

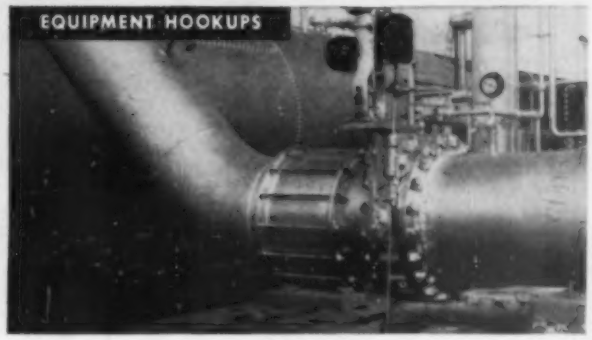
Test this powerful new welder yourself, and see the many advanced design features—new slow-down control, extra-rugged construction, and many others. Contact your nearby G-E Welding Distributor today. He's listed in the yellow pages of your phone book. Section 714-3, General Electric Co., Schenectady 5, New York.

EXTRA-STURDY construction is shown in this demonstration. Five nickels stand on edge while welder is operated at full load.

GENERAL ELECTRIC

IN THE OILFIELDS . . .

the DRESSER way is *easier . . . surer!*



As an oilman, you're interested in joining pipe quickly . . . maintaining tight joints . . . making fast repairs with minimum losses and shutdowns. Using Dresser Couplings and repair products, you can do just that.

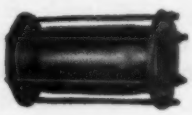
Dresser Couplings or Long Sleeves go together simply and quickly. Resilient Dresser Gaskets assure flexible joints which absorb settlement, other movement . . . on well and separator piping . . . salt-water lines . . . tank, pump, engine and compressor connections.

When a split, break or leaking joint occurs, Dresser Clamps and Sleeves turn an emergency into a simple repair job—completed in a matter of minutes *without shutdowns.*

You'll find there's a Dresser product for every condition and requirement affecting oilfield pipe lines, and that the DRESSER way is *always* easier, surer.

AVAILABLE AT ALL LEADING OILFIELD SUPPLY STORES

Style 38
Coupling


Style 40
Long Sleeve

Style 63
Expansion Joint

Style 39
Insulating Coupling

Style 55
Porous Weld Clamp

ALSO COLLAR LEAK CLAMPS, HIGH PRESSURE REPAIR SLEEVES

DRESSER®
COUPLINGS

Dresser Manufacturing Division, 49 Fisher Ave., Bradford, Pa. (One of the Dresser Industries). Warehouses: 1121 Rothwell St., Houston; 101 S. Airport Blvd., South San Francisco. Sales offices also in: New York, Philadelphia, Chicago, Toronto.

COMPRESSION RING . . . 1-piece, quick-seating. Maximum strength. Turned finish on outside diameter lets ring conform readily to the cylinder bore. The chemically treated surfaces aid rapid seating, no scuffing or scoring during run-in. ½″ to 120″ diameters.

POROUS CHROME PLATED RING . . . exclusive Van der Horst process. Shallow porosity on cylinder contacting surface facilitates break-in, holds and distributes oil during this critical period. Lasts four times longer, cuts cylinder wear up to 75%. ½″ to 42″ diameters.

CONFORMABLE OIL RING . . . maintains constant pressure for positive oil control. Conforms to meet cylinder distortion; flexible cast iron member, pressed outward by abutment type spring exerts uniform radial pressure around entire circumference. 4″ to 25″ diameters, ¼″ min. width.

KOPPERS SEAL RING . . . has one or two projecting bands of bearing bronze inserted in contacting face. Very quick-seating. Tends to prevent blow-by in new or worn cylinders. The burnishing action of bronze on cylinder walls decreases scuffing and wear. 2″ to 30″ diameters.

GROOVED OIL CUTTER RING...valuable where oil control is a major problem. Two bevels for riding over oil on up-stroke, two scraping edges for removing excess oil from walls on downstroke, plus a series of wide drainage slots. 1½″ to 25″ diameters.

Five Koppers Rings . . . worth their weight in gold!

What will American Hammered Industrial Piston Rings *do for you?* They'll save you money on fuel, on lubricating oil, on labor costs—by reducing down-time.

They'll maintain high compression, improve your operation, give you *much* longer service. They don't cost much . . . but they have over 35 years of manufacturing skill and accumulated experience behind them. They never let you down, they never fail in the jobs they're designed to do—and hundreds of satisfied users will tell you that, despite their low cost, Koppers rings *are* worth their weight in gold.

American Hammered Piston Rings are available in all types, all sizes—from ½″ to 10′ diameter—for every purpose. Koppers makes American Hammered Rings for all kinds of industrial equipment, can recommend without bias as to types. It costs nothing to consult Koppers—for illustrated Piston Ring booklet write to KOPPERS COMPANY, INC., *Piston Ring & Seal Dept.*, 1702 Hamburg Street, Baltimore 3, Md.

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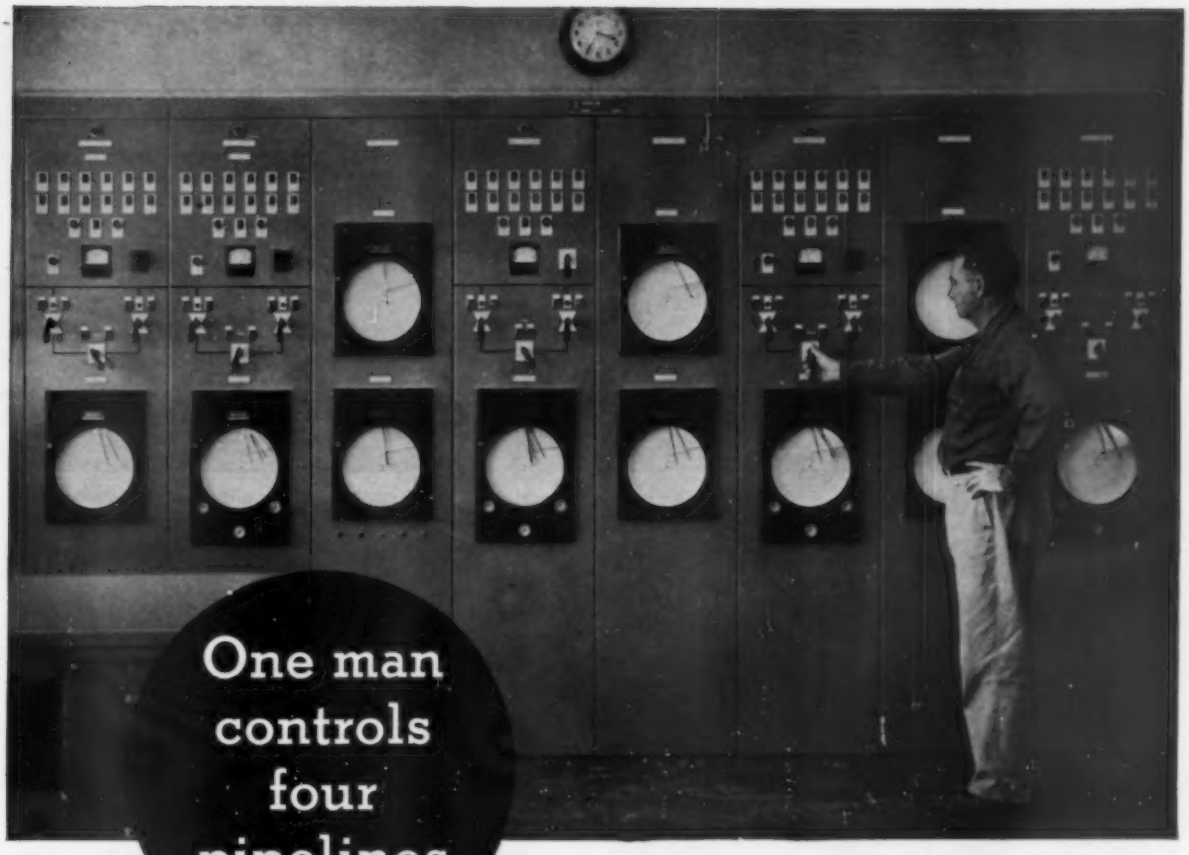
This Koppers Division also supplies industry with Fast's Couplings, Industrial Gas Cleaning Apparatus, Aeromaster Fans, Gas Apparatus.
Engineered Products Sold with *Service*

KOPPERS

AMERICAN HAMMERED
Industrial Piston Rings



One man controls four pipelines

. . . using panel of Brown instruments

FULL CONTROL of four different pipeline systems is centralized on a single Brown instrument panel, pictured above in the Carrolton, Mo., pumping station of the Service Pipe Line Company. At a glance, the operator can see exactly the values of flow and specific gravity of fluid going through each line, recorded on separate Brown instruments. For each line, a dual pressure recorder-controller charts the value of incoming and outgoing pressures . . . and automatically regulates the line valve to maintain economical operation and coordinated throughput of the pumping station.

Built into these instruments are industry-proved values of accuracy and sensitivity. Of particular importance to pipeline operations is their exceptional ruggedness and dependability. Each component and sub-assembly of Brown instruments is a standard, self-enclosed unit designed for long service and arranged to permit ready accessibility for inspection, maintenance or replacement. You're sure of reliable performance in installations which can run unattended or with minimum personnel.

Honeywell engineers are well qualified, by extensive experience in the field, to combine these basic instruments into systems custom-fitted for your specific pumping problems. And when you need service, either in emergencies or on a scheduled "preventive" basis, you're sure of prompt attention from the nearest of more than 90 Honeywell service centers.

For a discussion of your particular pipeline control applications, call your local Honeywell sales engineer . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.—in Canada, Toronto 17, Ontario.

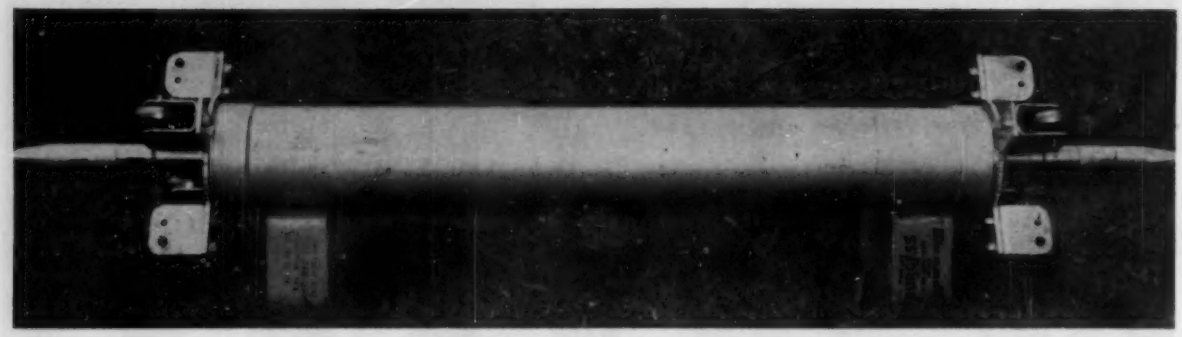
● **REFERENCE DATA: Write for Composite Catalog No. 5002 for a condensed listing of the complete Brown instrument line.**

MINNEAPOLIS **Honeywell**

BROWN INSTRUMENTS

First in Controls

THE MOLE . . .



The Mole ready for action. It is pulled through the underwater crossing 40 ft at a time. At each station it takes "shots" of the pipe line slope and direction.

. . . what it is

. . . how it works

W. F. Krueger
Sperry-Sun Well Surveying Co.
Houston, Texas

Basically, the instrument performs much the same tasks as a surveyor's level, transit and chain — *inside the pipe* on underwater river crossings.

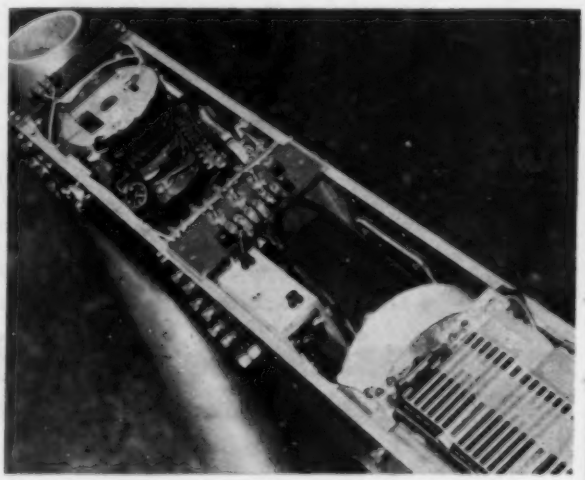
"WONDER what's happening to our Mississippi (or any other large river) crossing?" This is a question that pops up frequently in the minds of pipe line engineers. For underwater river crossings have been known to wander.

From the time a crossing is first laid in its underwater ditch several forces act to displace it. While it is being backfilled the buoyancy of the heavy clay or silt slurry tends to float it upward, and sometimes the banks of the ditch and even the back fill material tend to slip or cave. Even after the line is successfully backfilled, the river can scour beneath it, displace it and again backfill it.

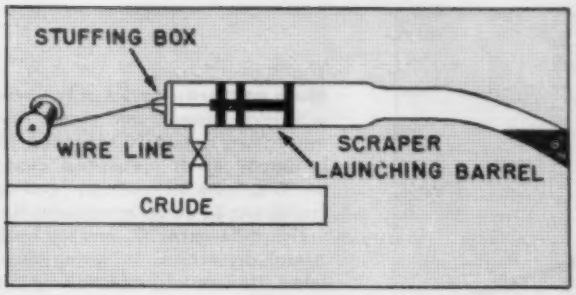
For example, not long ago a certain company had to make repairs on its Red River crossing. At the point where a new tie-in was to be made, the line had virtually disappeared. After a special pipe locator was devised, the line was found more than 100 ft from its original location. The river had scoured beneath the pipe, moved it to a new location and deposited a new sand bar over it.

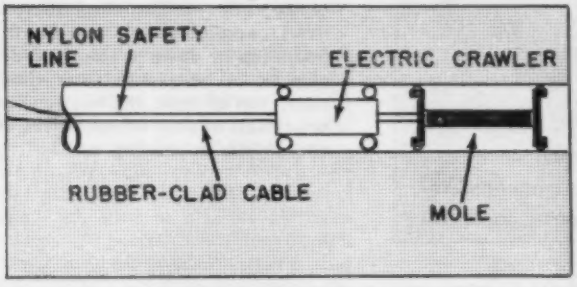
To solve this problem Sperry-Sun working closely with several pipe line engineers developed the "Mole". This new instrument is simply a modified version of an existing oilwell surveying instrument. For some years the oil industry has been drilling directional holes with uncanny accuracy, and the backbone of this technique has been the directional surveying instrument. It is this selfsame instrument that is the heart of the Mole.

The primary problem of develop-

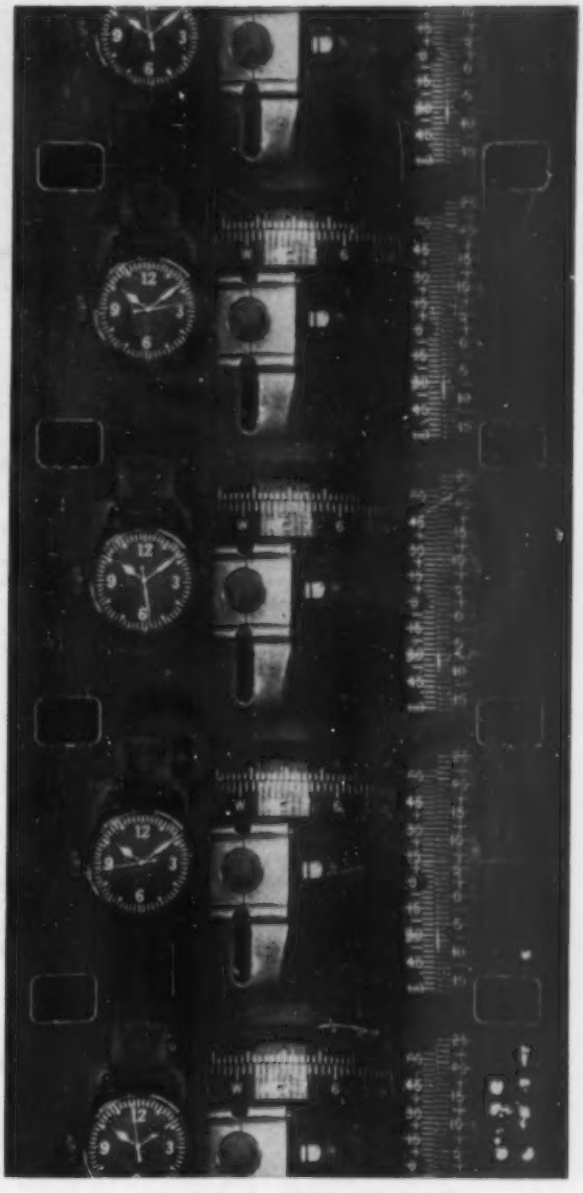


Inner workings of the Mole. Batteries in the right foreground and electrically timed camera just ahead focused on inclinometer and gyro verniers and clock. Inclinometer reads angles correct to 3 min; gyro correct to min.





Two ways of propelling the Mole through the line. Top shows a pig pulling a wire line through the crossing, which will later be used to pull the Mole through. Bottom shows electric crawler pushing the Mole through the crossing. In this instance, the rubber-clad cable is used for measurement.



Film record of the crossing shows instrument readings, which are taken every 40 ft or so. From these readings, IBM digital computers calculate Mole's path. Elevation closure to known end elevation averages about 1.2 ft per 100 ft difference.

ment of the Mole was to modify the instrumentation and field techniques of the oilwell surveying instrument (known as a "Surwel") to survey horizontally rather than vertically.

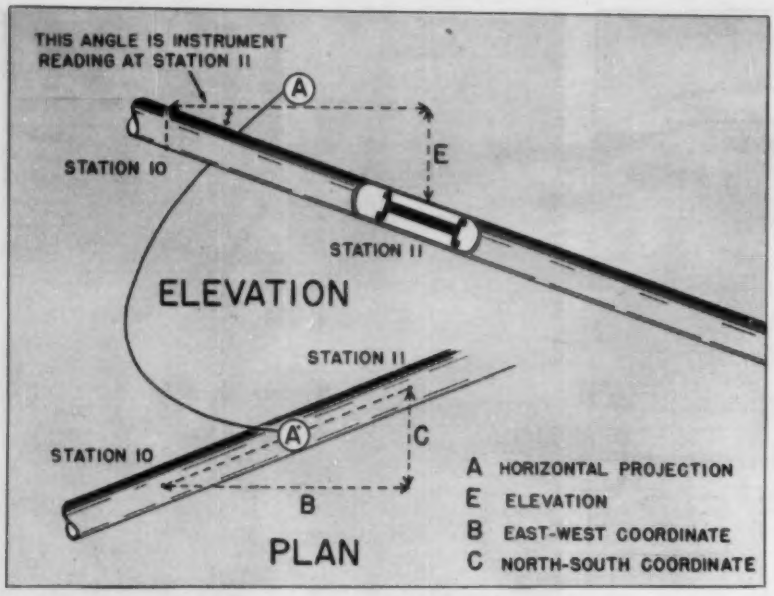
Basically, the instrument performs much the same tasks as a surveyor's level, transit and chain — **inside the pipe!** The level is replaced by an inclinometer, the transit by a gyroscope, the chain by wire lines, wire line meters and synchronized watches, and the surveyor himself is replaced by a movie type camera. The latter photographically records the three elements needed to obtain a pipe line survey. The direction element is the gyro and its scale and vernier provide bearings to 10 min of a degree of an angle. The vertical angle element is the inclinometer and its scale and vernier provide slope to 3 min of angle. The time of the record obtained by photographing the watch indicates the location of the Mole in the pipe line.

These instruments, parts, and other accessories all are mounted in a framework called the cradle. The cradle is supported inside a vapor-tight protective casing so that it acts as a plumb bob. Although the casing might rotate as it travels through the pipe, the cradle remains pendulous to permit proper functioning of the instrument parts. Also inside the case are dry cell batteries that supply the electricity needed for illumination of the instrument scales and for a timing device that single frames the camera every 15 sec. Once the operator starts the Mole it is self-contained and self-operated.

The instrument is designed primarily for use with two wire lines runing through the crossing. One line pulls the unit while the other serves as a back-up. Other forms of motive power are available, however, and eventually all of them will be used. An electrically driven pipe line crawler propelled the Mole through two 30-in. crossings of the Atchafalaya River. Also fluid drive in a crude or products line could provide the required motive power.

How the Survey Is Made

The first step in making a survey is to pull a wire line through the pipe line



Mole performs tasks of surveyor with level, transit, and chain. Distance from station 10 to station 11 is usually 40 ft measured along the line. From inclinometer reading (correct to 3 min of degree) the elevation difference "E" and the horizontal projection "A" are calculated. Horizontal projection "A" is transferred to plan of line and from the gyro readings (correct to 10 min of degree) the East-West (across river) coordinate "B" and North-South (up or down stream) coordinate "C" is calculated. Later, after return run of Mole, the two surveys are closed against known values of coordinates at crossing ends.

with a pig, compressed air, line fluid, or gas. If a crawler is available there is no need to place the wire line through the pipe.

The surveying begins after the operator has checked his instruments, started and oriented the gyro on a known direction, loaded and started the camera, and synchronized the instrument with surface watches. The cradle is then placed inside the outer casing and the end plates are bolted to the casing. Wire lines and swivels are attached to the end plates, wire line meters are placed on the lines at either end of the crossing, and the survey is begun.

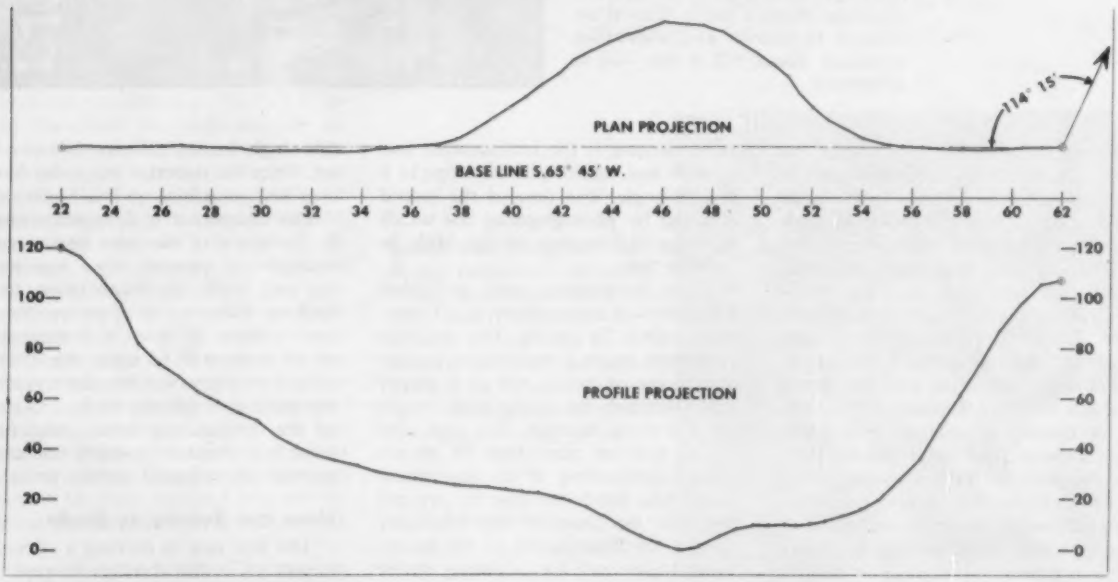
The Mole is pulled 40 ft and stopped for 25 sec to obtain at least one still record of the instrument readings. After the 25-sec pause, the Mole is advanced another 40 ft. This procedure is successively repeated until the entire length of the crossing has been spanned.

After the forward run has been completed, a reverse survey run is made, using the same increments and stopping at the same stations as the forward run.

The survey interval can be longer or shorter than 40 ft depending upon the pipe condition, but it has been found that this interval produces a reliable survey. Where there are short radius side, sag, and overbends the interval is usually decreased to 10 ft in order to detail more accurately these sections.

The survey film is developed as soon as possible after the field work has been completed. Records are read at each survey station to obtain pipe slope and direction. This information is tabulated for both the forward and

Typical plan and elevation of crossing calculated from Mole runs. Horizontal scale 1 in. = 200 ft. Vertical scale 1 in. = 20 ft.



A	B	C	D	E	F	G	H	K
016	02 00 —	S 70 40 W	.349 —	9.724W	2.305 S	52.676 —	355.078W	87.756 S
017	02 15 —	S 77 30 W	1.570 —	39.022W	8.651 S	54.246 —	394.100W	96.407 S
018	01 12 —	S 76 30 W	.838 —	38.886W	9.336 S	55.084 —	432.986W	105.743 S
019	00 09	S 75 40 W	.105	38.755W	9.902 S	54.979 —	471.741W	115.645 S

Example of IBM run sheet showing station number, A; slope or vertical angle, B; pipe direction, C; elevation increment, D; east-west increment, E; north-south increment, F; cumulative unadjusted elevation, G; cumulative unadjusted east-west coordinate, H; and cumulative unadjusted north-south coordinate, K.

reverse runs and then the two runs are compared to verify instrument performance.

Three dimensional coordinates of each end of the crossing are needed before the survey calculations can be made. Then computations are made for each station of the survey in a manner similar to a land surveyor's calculations. Pipe slope and measured length are used to find the elevation change, and horizontal distance of each survey leg. Horizontal distance and pipe direction are then used to find the horizontal coordinates of each station.

The forward and reverse runs are computed independently to determine the unadjusted coordinates of the survey end point. The difference between computed coordinates and known values is expressed as closure, and each survey is closed on the known end point by applying a straight line adjustment for the three closure corrections. The forward and reverse surveys are averaged to obtain a composite survey, and this survey is plotted in both plan and profile projections.

Survey number	Crossing length measured distance	CLOSURE VALUES					
		Elevation		East—West		North—South	
		Feet	% measured distance	Feet	% measured distance	Feet	% measured distance
6 In-run	1541	2.43	0.16	13.80	0.90	8.59	0.56
6 Out-run	1541	2.12	0.14	13.94	0.90	8.39	0.54
7 In-run	1510	3.34	0.22	3.68	0.24	1.27	0.08
7 Out-run	1510	4.55	0.30	3.69	0.24	2.12	0.14
8 In-run	3484	0.40	0.01	7.46	0.21	8.25	0.24
8 Out-run	3484	2.66	0.08	9.44	0.27	2.27	0.07
9 In-run	3493	2.56	0.07	25.78	0.74	7.24	0.21
9 Out-run	3493	3.53	0.10	27.80	0.80	16.25	0.47
10 In-run	8900	8.08	0.09	19.71	0.22	11.10	0.12
10 Out-run	8900	3.71	0.04	25.15	0.28	19.11	0.21
Average			0.12		0.48		0.26

How Accurate Is the Mole?

These closure values are an indication of survey accuracy. The accompanying table shows the three closure values for the last 10 survey runs (5 pipe lines) of the Mole. These values are expressed in feet and also in percentage of measured pipe length.

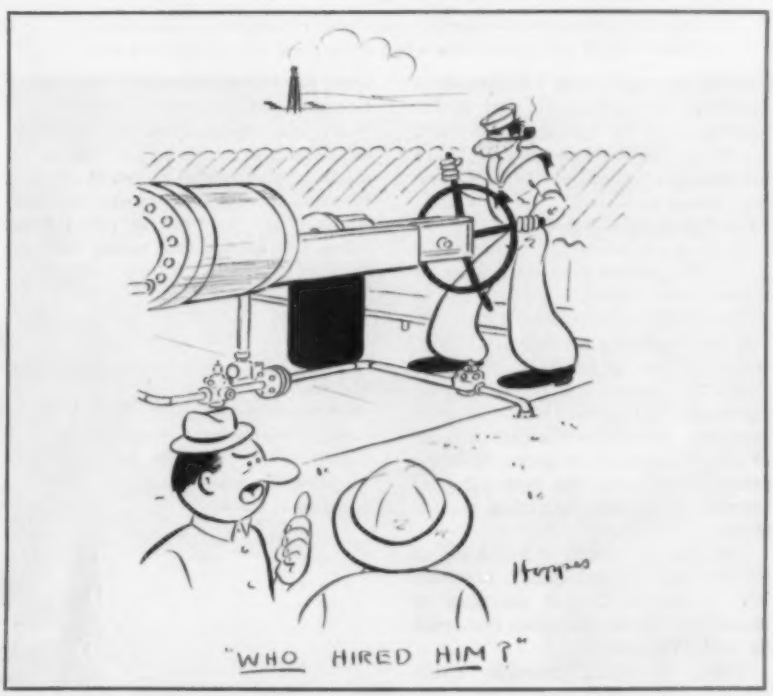
In actual practice, these computations are made on IBM digital computers. This speeds the final survey projections and eliminates computational errors.

To date, the Mole has been used to survey 10 river crossings. All were performed during the instrument's first year of operation. Three of these pipe line surveys were on Atchafalaya River crossings and the other seven were on Mississippi River crossings. Three of the crossings were old lines and seven were new. The size of the lines ranged from 16 to 30 in. and the length varied from 1200 to 9000 ft. The lines were filled with air-natural gas or crude oil.

Six of the new lines had been spot checked at favorable positions for elevation by lead lines, fathometer, and even divers. A comparison of the elevations so obtained with those of the Mole on its run tied in so closely that the small differences could not be directly attributed to either method of measurement. ★ ★ ★

The Author

W. F. Krueger is a native of New York City. He moved to Oklahoma in 1931 to enter Oklahoma University where he graduated as a petroleum engineer in 1935. He worked three years for the U. S. Bureau of Mines at the Petroleum Experiment Station in Bartlesville, later joining Sperry-Sun Well Surveying Company in a sales and engineering capacity. In January 1954, he set out to revamp oilwell surveying instruments to make horizontal pipe line surveys for underwater and marine lines. Since then he has run surveys on 10 river crossings.



A Northern master mechanic (above) checks out an expansion joint from a warehouseman. Distinct "797" on part is catalog item number.

The expansion joint (at right) is installed on a 2000-hp vertical engine. Then control system takes over.

EXCLUSIVE

No longer does locating a spare part resemble "looking for a needle in a haystack" at Northern Natural Gas — they're saving money and time with a . . .

Spare Parts Inventory Control

IN THE NATURAL GAS TRANSMISSION business, the right spare part in the right place at the right time can often prevent a possible emergency. That's the thinking behind Northern Natural Gas Company's new "Spare Engine Parts Inventory Control."

Spare parts inventory control is a system designed to keep track of spare engine parts warehoused at 29 of Northern's 33 compressor stations. It had its beginning in January, 1954, and is carried on jointly by the company's compressor and accounting departments. During the 18 months of its existence, the system has proved itself so effective that it is currently being extended to cover the materials and supplies of all the operating departments.

The control system is not designed just for times of emergency, however. It's a functional plan designed to answer the routine questions that come up every working day.

Here's a typical example. Every spare parts requisition forwarded to the Compressor Department in the Omaha, Nebraska, main office for approval is checked to see if any of the items might be available in excess at another location. If so, a stock transfer is issued transferring the part to the station where it is needed thus saving the cost and time of ordering it from the manufacturer and at the same time reducing an excessive inventory.

The expense of developing and maintaining such a system is relatively small when considering the fact that Northern's investment in spare engine parts is in excess of $1,700,000.

The plant clerk types a stock issue ticket which reports transaction to Omaha office. Every time a transaction takes place a report is made.

Everything Is Catalogued

The first step in developing the system was the cataloging of over 5000 different types of spare parts. These 5000 different types total some 70,000 individual parts. Cataloging was a tremendous job requiring an accurate description and value of each item, assignment of a catalog number, and cross-referencing of all interchangeable parts.

Preparing the catalog was complicated by the fact that Northern's compressor stations were built over the entire 25 year period of the company's history and the units in use were made by seven different manufacturers. Consequently it was necessary to catalog parts for 13 different types of auxiliary engines, 33 different types of compressor cylinders and 22 different types of compressor engines.

Over the years, a great many of the major assemblies on the older units were radically changed to incorporate new advances in engineering thus making some parts obsolete and in many instances rendering the original manufacturers' catalogs unusable as a guide in preparing Northern's catalog.

The resulting 380-page catalog took approximately eight months to complete. It is divided into three broad classifications—auxiliary engine parts, compressor cylinder parts and compressor engine parts. These three major groups are broken down into specific classes based on manufacturer. In all, there are eighteen classes assigned to engine parts. Within the class ,each type of unit is listed, broken down by major assemblies and their component parts in alphabetical order. The breakdown is natural and already familiar to field operating personnel, making the catalog easy to use and understand.

To make certain that the catalog description of the part corresponds to the actual part in the warehouse, each part is marked with the catalog identification number thus making positive identification in the future a simple matter. The catalog numbers are also used on requisitions when new parts are ordered and all manufacturers have been supplied with copies of the catalog to assist them in filling Northern's orders more accurately.

Provision was made to revise the catalog as often as necessary when new parts are to be added and obsolete parts dropped, or whenever it is necessary to correct an error in the original listing. The entire catalog is set up on machine accounting punch cards with a master card on file for each type of part.

Revising a page of the catalog is simply a matter of running the master cards for that page through the machine accounting tabulator, incorporating the changes. The new page is printed in two or three minutes compared to about 45 minutes for typing a page of such highly technical material.

The parts warehouse at Northern's Palmyra, Nebraska, compressor station is typical of many up and down Northern's system. Spare parts are stored at 29 of the 33 compressor stations on the Northern system.

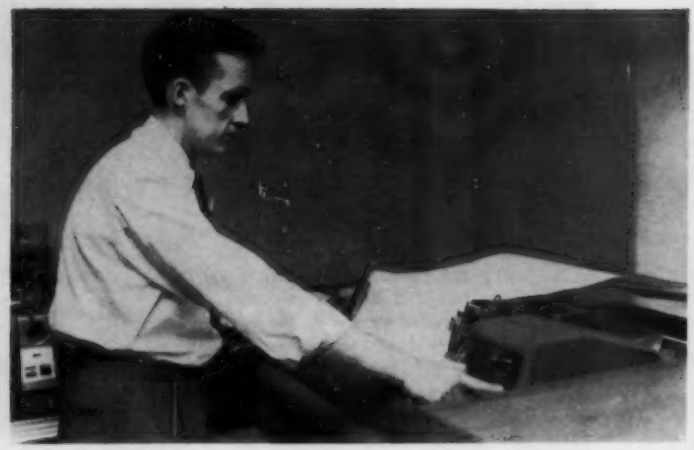
Reporting Parts Transactions

Although cataloging and the resulting positive identification of all parts is the foundation upon which the whole system is based, it would be of little value by itself. To put the system to work so that it would accomplish its primary purpose of control, it was necessary to devise a method of reporting spare parts activity. There are some 1500 to 2000 transactions monthly; that is, parts received in stock, used in maintenance, or transferred from one location to another. These transactions are reported from the field as they occur.

From these field reports, a machine accounting card is punched for each transaction. These transaction cards plus some 12,000 "balance forward cards," which carry the previous month's balance of each item at each location, are used by the machine ac-

The interiors of Northern's compressor warehouses are neatly arranged with marked bins for small parts and ample storage for larger items.

A key punch operator of Machine Accounting in Omaha transfers information on expansion joint from stock issue ticket to punched card.



Another Machine Accounting employee keeps an eye on the tabulator as it prints one of several reports required for spare parts inventory control each month.

counting section in preparing the following monthly reports:

1. The Monthly Inventory of Spare Parts, which lists all parts and shows date of last transaction, where warehoused, unit price, quantity on hand, year-to-date use and total value. This report is on a system wide basis and is especially valuable to the Compressor Department in locating parts stored at one location which are needed at another location.

2. The Detail Spare Engine Parts Ledger is similar to a monthly bank statement. It shows the spare parts activity and year-to-date usage for each warehouse and is particularly important to the Compressor Superintendent of the location concerned. It provides a complete record which he can check against his station inventory thus detecting any errors with a minimum of delay. The year-to-date usage column is of special interest to the superintendent since he can readily see which items are not used at all or needed so infrequently that the number on hand should be reduced.

3. The Materials and Supplies Summary Report shows the month end money balance and the amount of increase or decrease in inventory value for the current month and the year to date, each class of material at each warehouse. Management finds this report especially helpful since it quickly points out large increases or decreases in inventory that require attention and shows the trend that the overall inventory is taking.

Calculator Speeds Operation

Since the usefulness of these reports is directly related to how current they are, speed in preparing them is essential. About four working days prior to the end of the month a cut-off is made by the Accounting Department and all reported transactions received up to that time are included in the reports for that month. Approximately a week later, or about the first or second day of each month the reports are completed.

The key to keeping the reports current is the electronic calculator used by Northern. The calculator is able to process 100 punched cards per minute, or for example, it can take a "balance forward card" for the previous month, four transaction cards, a new balance forward card and complete 18 calculations in 3½ seconds. This compares with approximately five minutes to perform the same operation manually.

The calculator is selective, too. In computing the new average price of parts after a purchase has been made the calculator will stop and flash a red light anytime the new price exceeds the old one by 50 per cent. Thus the price paid for the parts can be checked to make certain the company has not been overcharged.

☆ ☆ ☆

Tulsa Short Course For Pipeliners Set

The February 15-17 Seventh Annual Corrosion Control Short Course for Pipeliners will be given by Tulsa Section at the Mayo Hotel, Tulsa. Lectures, demonstrations and discussions of pipe line corrosion and its control will be featured.

The instruction is designed for pipe line foreman, superintendents, field engineers and inspectors. Non-technical presentations of the principal aspects of the causes of corrosion, measurements and instrumentation, pipe coatings, galvanic anodes, impressed currents, etc., are scheduled.

While reduction of stock is a natural and desired effect of any inventory control plan, it is not the first objective. As Northern's Superintendent of Compressor Stations A. L. Vaughan points out, "it would certainly be undesirable to reduce stocks to a point which would interfere with company operations. Northern's system is designed with the thought in mind that the lack of a single part can stop an engine and consequently the primary purpose of the system is not to reduce inventory, but to make the most efficient use of it. In effect, it enables the Compressor Department to operate more efficiently with a smaller inventory and therefore a smaller investment in spare parts."

Interchangeability Data Provided

The new system has proved its worth in other ways, too. Complete data on interchangeability of parts which can be used on various types of equipment is immediately available. Costs are more easily controlled since the Compressor Department has a complete picture of what actual maintenance costs are. These cost studies in turn provide a guide for future purchases and replacements of compressor equipment. In addition, the reports provided by Machine Accounting give management a monthly check on inventory values and thus many problems may be averted or remedied before they become serious.

The test of any system is its ability to perform day after day doing the job it was designed to do. Spare Parts Inventory Control has met that test by combining operating economy and convenience with the essential control needed by management to guide the affairs of a major transmission company. ★ ★ ★

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Vapor-Phase Cooling

A symposium of importance to all users of internal combustion engines

Why this symposium?

A four-part discussion

Ever since man invented the internal combustion engine, he has been faced with the economical and mechanical problems of their unused heat. Today, a method—by which heat is removed by boiling water in the engine jackets—is being successfully used on many installations. Known as Vapor Phase Cooling, it costs less to install, uses less power, and gives better engine performance than conventional jacket-water cooling. It also effects substantial savings in fuel, water, and equipment if the steam can be utilized. For these reasons, everyone who designs or uses internal combustion engines should be interested in further use and development of VPC.

A basic cooling concept can mean lower operating costs

VPC provides heat absorption without temperature rise; reduces amount of equipment needed

Brock Mott
The Mott Company
Houston, Texas

THERE has been a steady evolution in the cooling of internal combustion engines that is culminating in improved engine maintenance, reduced fuel and lubricating oil consumption, lower auxiliary power requirements, and other substantial savings, all of special significance to the gas industry, which relies heavily on such machines. While most improvements to equipment result in higher first cost, it is interesting to note that these beneficial effects are possible at a reduced installed cost of cooling system.

Tracing this evolution, let us first look at the heat dissipation of modern internal combustion engines. Less than a third of the total energy of the fuel is converted into useful work. Another third goes out the exhaust to the atmosphere, while the remaining third is rejected to the metal encasing the combustion chamber.

It is important that this heat rejected to the metal be efficiently carried away so as to preserve the conformation and design clearances of internal moving parts without deterioration of the lubricant. This basic cooling concept emphasizes the importance of *maintaining uniform metal temperatures*, rather than maintaining any arbitrary coolant temperature level. Part of this heat is transferred from friction parts to the lubricating oil, but the larger portion is dissipated through the liner wall and cylinder head to power cylinder jacketing, which employs water coolants.

Engine designers apparently lost sight of these basic cooling requirements of their machines, since not many years back it was common practice to cool engine jacket water to 120 F or less, with temperature rise across the jackets in excess of 25 F, causing high metal stresses due to cold-jacket metal restraining expansion of the hot cylinder parts and unequal expansion between bottom and top of cylinder.

With the advent of aerial cooling some 15 years ago, engine designers were forced to higher jacket temperatures and reduced cooling ranges to keep cost of cooling systems down.

Operators noted that the engines performed just as well at these higher temperature levels. In fact, the higher temperatures reduced crankcase sludging, with consequent improved lubrication and less wear on moving parts. Lower temperature differential across the jackets also contributed to fewer cracked heads and liners, apparently due to reduced metal stresses and more uniform expansion of hot metal.

Today, it is fairly accepted practice to cool engine jacket water from 170 F to 160 F, and although a few opera-

tors still take exception to these temperatures, many are more inclined to strive for even higher temperatures and lower rise for the benefits so derived. Vapor-phase cooling carries this trend in engine cooling to its ultimate objective, by permitting the phenomena of heat absorption without temperature rise.

Vapor Phase Cooling

The term "vapor-phase" cooling is somewhat misleading in that it implies that jacket cooling is accomplished by vapor being circulated in the jackets. Actually, the jackets are full of water, and only a relatively small amount of steam is generated. Other more descriptive terms are *boiling point cooling, latent cooling,* and *ebullient cooling.*

By permitting the jacket water to boil in the jackets, the engine is cooled by the latent-heat absorption capacity of the water. Thus, if the water is introduced to the system at the boiling point, it absorbs the heat from the hot metal surfaces by partial evaporation without significant change in temperature.

Under these conditions, the water temperature is automatically controlled by the pressure kept on the system, and no costly three-way valves or other temperature controlling devices are required to maintain a constant coolant temperature.

How It Works . . .

The jacket water pump used with other cooling systems is eliminated. Upon start-up of a cold engine, conventional sensible heat absorption takes place with the water static in the jackets until it reaches the boiling point, at which time fine steam bubbles appear at the hotter parts of the jacket. As these bubbles detach from the wall and rise in the jackets, they promote circulation of the water out of the jackets to a steam water separator.

From the bottom of this separator, the heavier column of water returns to the jackets without intentional cooling. Due to the difference in density of the two columns of water, a rapid circulation is induced that is more than sufficient to assure an ample supply of water in the jackets at all times. With proper design, a circulation rate of approximately 20 lb of water per lb of steam may be maintained at full load.

The system described is comparable to a water tube boiler, with the power cylinder jacketing serving as the tubes and the separator as the steam drum. The one significant difference is the circulating of a higher ratio of water to steam, assuring lower heat flux and constant wetting of hot surface. By designing a cooling system (keeping in mind various principles of boiler design), you end up with a workable engine cooling system.

Obstructions to flow should be removed to prevent formation of steam pockets, and where lines out of the jackets are not adequately sized to accommodate the volume of water and steam at atmospheric conditions, additional jumpers or larger lines should be installed.

The separator should be located with as short return lines as possible, and these lines should be insulated to further minimize heat loss through radiation. The steam condenser may be located close to or away from the building, as desired.

If the condenser is properly elevated, the condensate can drain by gravity back into the system, preferably to one of the water-steam headers or the steam drum in order that subcooled condensate may be heated back to boiling point while condensing steam and reducing the condenser load.

. . . and Its Advantages

The advantages of the boiling cooling system have been recounted many times before:

(1) More uniform metal temperatures due to no appreciable temperature rise across engine jackets.

(2) Better heat transfer to metal surrounding the jackets, thus reducing metal stresses and lessening distortion of contained hot metal parts.

(3) Protection from effects of cylinder condensation, sharply reducing corrosion and permitting use of lower grades of fuel.

(4) Reduced blow-by due to more even expansion along the length of the liner, thus reducing lube oil contamination and reducing oxidation rate of the oil normally caused by contact with these hot gases.

(5) Improved lubrication due to elimination of sludging and reduction in dirt load.

(6) Reduced fuel and lube oil consumption.

(7) Availability of waste heat at useful temperature levels.

(8) Greatly reduced cooling system investment.

(9) Reduced utilities.

Literature of the past two years has dwelt at length on the maintenance and operating advantages of this system; these advantages are intangible to an operator trying to justify installation of such a system for the first time. The system may be economically justified, however, in almost any case through full consideration of the latter three points.

Waste Heat Recovery

Thus far, jacket pressures with the boiling cooling system have only been carried as high as 26 psi. Higher operating pressures seem feasible if design pressures of jackets will permit it. There are, however, many applications for steam at these levels.

In the northern climates, building heating in the winter is an excellent use for this steam. It can also be used in the summer in an absorption refrigeration cycle to air condition adjacent offices or chill the intake air to the engine. There are applications for this heat in oil producing areas for heating crude oil. As engine designers allow jacket pressures to be increased, more uses for this waste heat can be found.

Another interesting possibility for waste heat recovery is the exhaust heat normally dissipated to atmosphere. Steam generated by exhaust gases can be obtained from low pressures to levels as high as 200 psi. This brings up the possibility of using this higher pressure steam for jet boosting the lower pressure steam now recoverable from engine jackets.

Reduced Investment

Savings in heat-transfer surface to cool the jacket water result because of higher overall transfer rates and higher MTD. This saving could amount to more than 40 per cent of the usual aerial jacket water-cooler surface needs, which represents a substantial saving in first cost. Dwarfing this saving, however, is the cumulative reduction in cost of pumps, foundations, piping, valves, temperature controls, tanks, electrical wiring, and power generating equipment. The significance of these attendant savings will amount to four or five times the saving realized in heat-transfer surface alone.

An Answer to Rising Costs?

The gas industry, faced with reduced margins of profit due to higher rates of federal and state taxation and control, increased operating costs, and sales price of gas and liquid products that has not kept pace with increased overhead costs, must continue to seek means of reducing capital investment and lowering operating costs to maintain its competitive position. Vapor-phase cooling of internal combustion engines is one answer to this challenge.

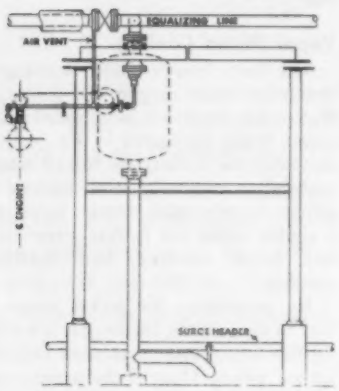
★ ★ ★

P 624.5

United Gas Pipe Line added five 880-hp units, cooled by VPC . . .

Vapor phase cooling system designed for a station using 8-cylinder, 880-hp engines is shown here. Major changes were in piping arrangement.

End view.



Application brought problems; solution found by making engine design changes

C. D. Long
Assistant Superintendent
Compressor Department
United Gas Pipe Line
Shreveport, Louisiana

APPLICATION of vapor-phase cooled gas engines to gas compressor station operation by United Gas Pipe Line Company was made with two prime objectives in mind by its installation. First, the objective was to reduce waste heat from gas engines and convert it into useful work in compressor stations. The second thought was to take advantage of the probable benefits of such cooling in the use of an adverse engine fuel.

Original thinking along this line began about 1952 and proceeded through design to the point of purchasing a low-pressure steam turbine for driving the fin-fan unit used to condense the steam produced in the engine jackets. Economically, this was found to be unsound, and the idea remained dormant for almost a year. It was then decided to substitute hydraulic drives powered by the engines for these cooling fans.

Probable benefits that would arise from use of this system with adverse fuel concerned the reduction of crank case sludge and crank case acid that would result in reduced oil filtration and overall engine maintenance cost.

Actual application of the system was decided upon to be at UGPL's Agua Dulce compressor station, where there already were four 8-cylinder, 440-hp engines in operation. Additional horsepower was presently needed. Consequently, it was decided to install five additional 880-hp engines, each driving two 10¼-in. by 14-in. compressor cylinders. The engine manufacturer was advised of these plans in advance of the purchase of the engines, and it was decided to make the following changes in design in piping from the conventional water-cooled type engine.

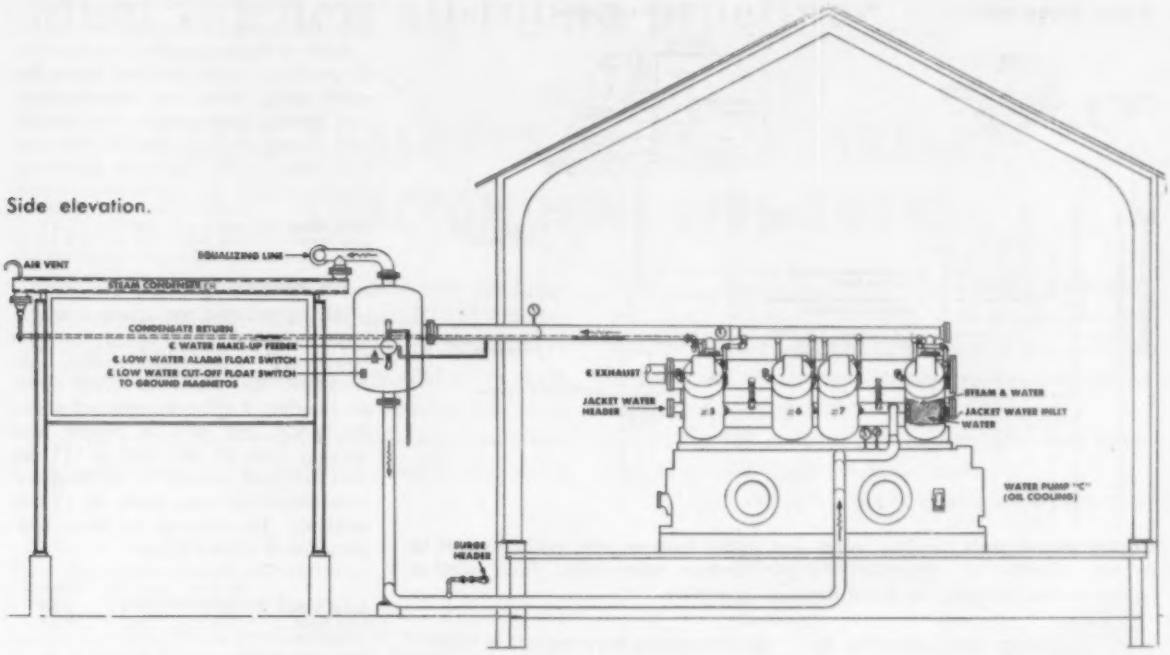
1. Provide one 8-in. steam manifold for the engine.
2. Install additional 1½-in. outlets from each cylinder head to the steam manifold.
3. Use the conventional jacket water pump for oil cooler service.

These changes were correlated between two manufacturers' supply equipment by UGPL's engineering department, and plans were completed for the installation in 1953.

On January 2, 1954, the five engines were individually broken in by operating 24 hr with no load, 6 hr with ½ load, and 6 hr with ¾ load. Throughout the break-in period, no unusual conditions were noticed in the operation of any of the engines by engineering personnel from all three companies involved in this project.

Initial operations of the five units commenced on January 5, 1954, with the following approximate conditions:

1. Suction, 425-psi; discharge, 685-psi; R = 1.6.
2. Delivery—100,000,000 cu ft per day.
3. Jacket water; in, 209 F — out, 212 F.
4. Oil in, 140 F — oil out, 165 F.



Side elevation.

5. Speed — 330 rpm.

6. Manifold depression — 9½-in. mercury.

7. Fuel consumption—8.2 cu ft per bhp-hr.

Operation of the engines was watched closely and diligently around the clock by both the operating company personnel and the manufacturers of the equipment.

Here's what happened . . .

To properly understand the events of the following several months, it is necessary to list these in the most logical sequence, which is not necessarily the sequence in which they occured.

1. On January 8, 1954, three days after starting, light to medium-power cylinder knocks were noticed in all five engines. These knocks were most prevalent and noticeable on the left bank of cylinders, (cylinder No. 1 through 4).
2. From January 9 to January 14, 1954, cylinders were inspected and wear measurements taken as rapidly as possible by the operating personnel.
3. From January 15 to September 2, 1954, a complete changing of cylinders, pistons, and rings was accomplished.
4. On January 18, 1954, a conference was held on the site by the designers, manufacturers, and operators.
5. During the week of January 22 to January 29, 1954, cylinder and water-temperature checks were made throughout one engine.
6. On February 5, 1954, identical temperature checks were made on a conventionally cooled engine of the same type.
7. From February 11 to July 7, 1954, chemical analysis and hardness test were run on original liners, pistons, and piston rings.
8. At intervals between August 16, 1954, and January 18, 1955, complete cylinder inspections were made on engines after 3000 hr of operation by individual engines.

The findings of the inspection of January 8, 1954, were scuffing, scoring, scratching, galling, and extreme wear in most of the cylinders. It was in fact found that one cylinder had a wear of .017-in. after 33 hr of operation.

These facts dictated radical modification and maintenance measure. It was first decided that the removal of ring No. 7 from the skirt of all pistons would assure lubrication even to excess in all cylinders. Further, it was decided to change the crank case oil in No. 6 engine from 30-wt to 40-wt oil.

Also, a complete oil analysis would be run on oil from each crankcase. In order to keep at least four engines on the line while the fifth was receiving the modifications already decided upon, a decision was made to use an oil additive. This additive contained molybdenum disulfide.

Several modifications . . .

All of these steps were taken with greatest speed possible, and a second inspection of No. 5 engine was made January 19, 1954. The result of this inspection showed a slight decrease in the wear rate. Though the wear continued, the decrease in rate was encouraging.

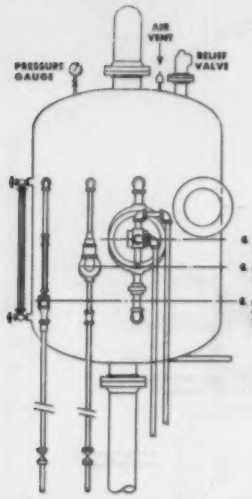
It was concluded, however, at this time that most likely there were points of heat concentration in the cylinder jackets and that free thermal flow was hindered by the two jacket baffles. The first step was to place 1-in. by 1½-in. notches in both these baffles every 90 deg around the cylinders. An additional 1-in. jumper would be installed between the top of the jacket and the bottom of the cylinder head.

The manufacturer had designed a new-style piston for this engine with ¼-in. ring grooves instead of ⅜-in. grooves with better heat control and dissipation, and the pin cavity had been removed from each side of the piston. These new pistons were to be furnished by the manufacturer on an emergency basis, and the operators were willing to accept and try them.

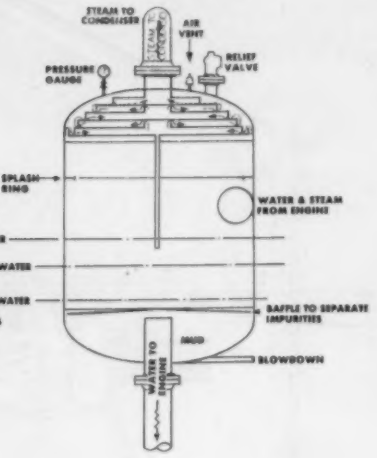
Complete and exhaustive temperature checks were to be made throughout the cylinder heads, cylinder jackets, and liners of one engine. As quickly as this could be done, the results were to be compared to identical readings from a conventionally cooled engine.

The idea of running a chemical analysis and hardness test on liners,

Vapor phase unit.



Sectional view.



Vapor phase unit receives water and steam from engine, returns water to engine, is baffled for separation of impurities from return water. Float switches on unit protect against low water damage to engine.

pistons, and rings was conceived by the operator wherein he understandably stood alone.

. . . with good results

Results of these modifications and analysis were gratifying once the work was complete. The removal of the No. 7 oil ring did not noticeably increase the oil consumption by these engines. Neither did it visibly affect the operation in any way. The change from 30 to 40-wt oil in engine No. 6 was written off as an experiment without favorable results, and the oil in this engine was soon changed back to conform with the others. Laboratory analysis of the oil was not indicative of lubrication failure, oil break down, or a gain or loss in viscosity.

The use of oil additive with molybdenum disulfide, it was felt, allowed continuing operation of the engines during the cylinder modifications without complete engine failure.

It should be pointed out that this is a belief held by the operator although there is no proof of such because no attempt was made to continue to operate one engine without this additive. Neither is it intended as an indorsement of that or any product mentioned here.

Temperature checks reveal . . .

Running of temperature checks throughout one engine and the results of this check was one of the most interesting phases of this entire operation, which, as of February 1, 1954, would certainly be classed as experimental.

Cylinders No. 3 and 7 of engine No. 9 were selected for this test. Fifteen thermocouples were inserted in each of these cylinders and the results read with a 20 point potentiometer. Four thermocouples were placed in the cylinder head water with two above and two below the head baffle. Three thermocouples were placed in the cylinder-jacket water with one each above, between, and below the two jacket baffles.

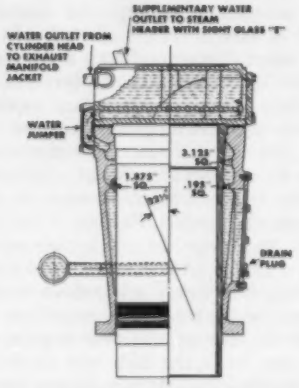
Liner metal was drilled ¼-in. deep inside the "V" at 45 deg with the shaft 7, 11, 13, and 20 in. from the top of the liner and thermocouples inserted and sealed off.

The remaining thermocouples were installed in similar locations outside the "V" at 180 deg around the liner. The jacket baffles in No. 3 cylinder were notched every 90 deg around the jacket while No. 7 cylinder was left with the standard factory notches.

Both of these cylinders had the 1½-in. auxiliary outlet installed below the head baffle. With this thermocouple and piping arrangement, this engine was placed under a normal load and trial temperatures taken as indicated:

	No. 3 cyl.	No. 7 cyl.	Difference
Jacket Water	213 F	214.6 F	1.6 F
Liner Metal	213.9 F	219.1 F	5.2 F

Cylinder view.


SUPPLEMENTARY WATER OUTLET TO STEAM HEADER WITH SIGHT GLASS "S"
WATER OUTLET FROM CYLINDER HEAD TO EXHAUST MANIFOLD JACKET
WATER JUMPER
3.125" SQ.
1.875" SQ.
.193 SQ.
DRAIN PLUG

Water circulation through cylinder is shown in this sectional view.

. . . a heat congestion

All agreed that the above temperatures indicated a heat congestion or a bottle-neck in the jacket system. Accordingly, the 1½-in auxiliary outlet on the No. 7 head was placed above the baffle, and with an engine load varying from 92 per cent to 115 per cent full load, a series of ten temperature recordings was made at 15-min intervals. The average of these temperatures is shown below:

	No. 3 cyl.	No. 7 cyl.	Difference
Jacket Water	214.1 F	218.4 F	4.3 F
Liner Metal	216.1 F	219.2 F	3.1 F

It must be remembered that these temperatures rose to this point from an inlet water temperature of 209 to 210 F so that the maximum temperature rise across these cylinders was 10 F.

With the knowledge that these temperatures were elevated and the corresponding temperature rises were normal, it was concluded that, perhaps, there was a considerable temperature gradient between the cylinder skin and heat-transfer surface.

The thermocouples were removed from the liner and reset within ¼-in. of the cylinder surface. The maximum temperature recorded at this distance from the cylinder, however, was 228 F, which certainly could not be considered abnormal when compared to the inlet temperature of 209 F.

Comparisons Made

Closely following this, identical tests were run on cylinders of a conventional liquid-cooled engine that normally runs with 150 F water on and 160 F water off the jackets. Measured temperatures at this location were only 60 to 65 F lower, and because the water to these cylinders were normally only 60 F below the water to the vapor-phase engine jackets, it was concluded that there was a problem of only two parts — namely, to increase thermal circulation or to procure liners, pistons, and rings of metal compatible at the operating temperature. A combination of these was possible.

It had already been decided to notch the cylinder baffles, install the auxiliary outlet above the head baffle, and use the new-style pistons. To alleviate thermal circulation, it was decided to

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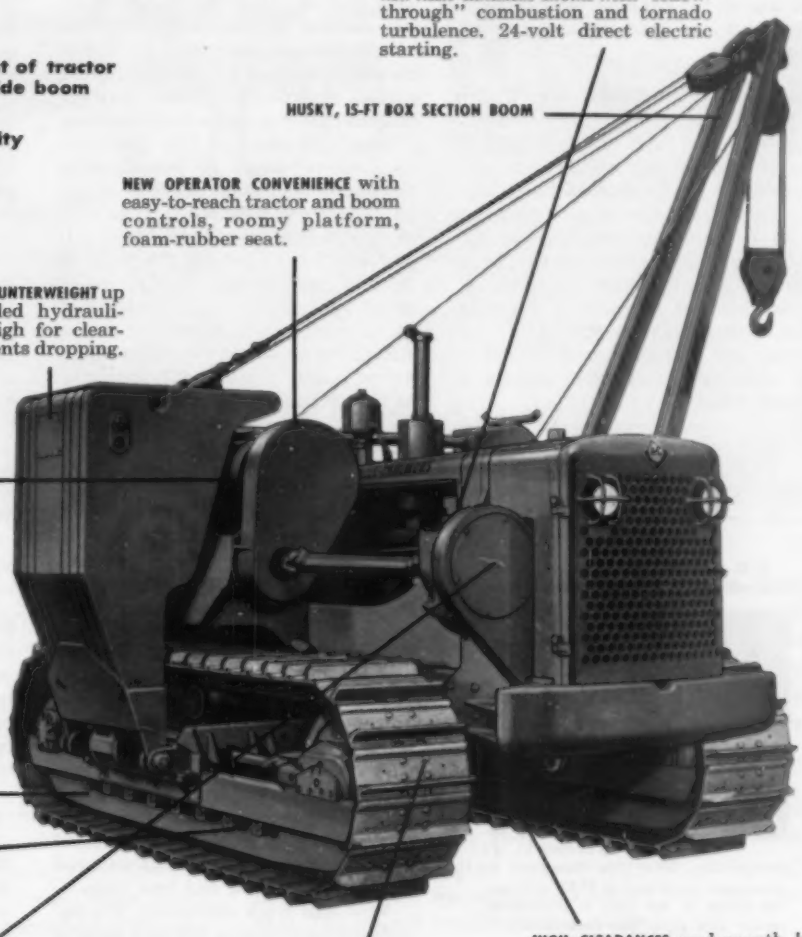

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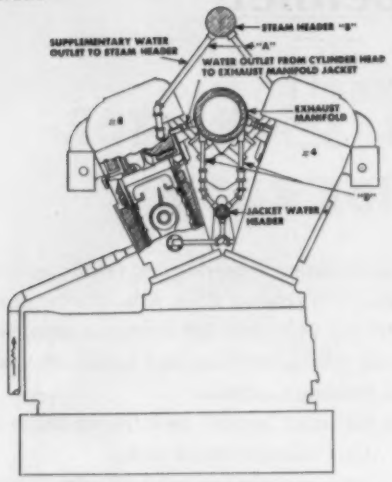
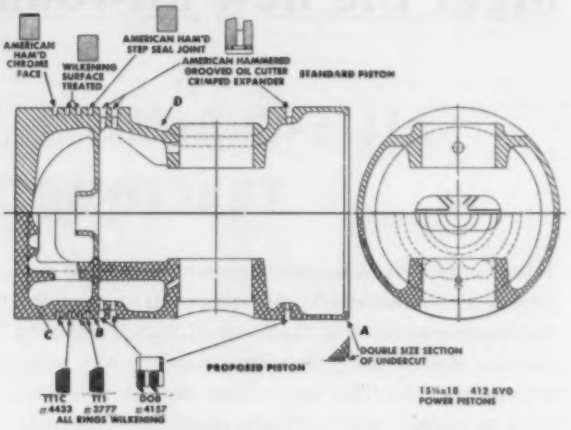
ALLIS-CHALMERS

Engine view.



Jacket water cooling flow.

Piston view.



Piston, ring changes are shown in comparison views. Top view shows standard equipment, bottom section shows proposed equipment.

install an additional 1-in. jumper from the top of the cylinder jacket to the bottom of the cylinder head on all engines.

Hardness Tests Made

No chemical analysis nor any hardness tests had been made on any of the metals showing severe wear. Accordingly, samples of worn liners, pistons, and rings were sent to three reputable testing laboratories. At the same time, the manufacturer was requested to furnish specifications on these materials. Reports from these laboratories were very similar in every detail, and the average hardness of the materials from these reports is shown below:

Brinell hardness of liners	178
Brinell hardness of pistons	196
Brinell hardness of rings	199

The Author

C. D. Long was born at Roscoe, Texas, and received his degree in mechanical engineering from Texas A&M college. From 1934 to to 1939, Long was connected with the engineering department of the York Corporation at Houston, Texas. He joined the engineering department of United Gas Pipe Line Company at Shreveport, Louisiana, in 1940, with special duties in the field of compressor station and pipe line construction. In 1950, he was transferred to the compressor station department of that company, where he has continued since that time, and is presently assistant superintendent of the department. He is a member of the Registered Professional Engineers of the State of Texas.

Final corrective maintenance steps were now in order. The manufacturer was advised of the findings by the laboratories and instructed to furnish enough new liners for one of the five engines. A second set of new liners was ordered from a concern recommending a Brinell Hardness of 230 minimum. As previously stated, the manufacturer was furnishing pistons of a new design for all engines. New piston rings were to be installed on all engines also. It was felt that of the 40 cylinders on these engines, enough of them could be salvaged to place good cylinders on the remaining three engines. In fact, it was agreed not to use any old cylinders having a wear in excess of .005-in. and to rebore 1/32-in. maximum oversize on cylinders that would clean up satisfactorily.

Changes Made in Engines

As the material arrived, engine No. 5 was equipped with the new pistons and liners. Because sufficient replacement rings were in stock to equip this engine, the new pistons were specified to have the standard ⅜-in. ring grooves. Engine No. 6 was equipped with new liners having a 230 Brinell Hardness, new-style pistons, and new narrow rings. Engine No. 7 received salvaged liners from other engines, new-style pistons, and rings. Engine No. 8 was equipped with liners rebored to 1/32-in. oversize, new pistons, and new rings. Engine No. 9 was treated the same as engine No. 7 with salvaged liners, new pistons, and new rings.

With this work completed, the station was carried on a full-load basis as dictated by demand, and it was decided that, unless an emergency arose, no further inspection or changes would be made until the individual engines reached 3000 hr of operation after modification.

Three Thousand-Hour Inspection

The No. 5 engine was the first to reach this 3000-hr period and was inspected with the following results:

Cyl. No.	1	2	3	4	5	6	7	8
Wear (in.)	.009	.005	.005	.004	.004	.004	.005	.004

The average wear of .0016-in. per 1000 hr was not alarming or entirely satisfactory. It must be pointed out that the 1-in. jumper from the jacket to the bottom of the cylinder head had not been installed before this inspection and that the rings in this engine were still ⅜-in. instead of the new ¼-in. standard. Operation had been entirely satisfactory at all loads; there was a smooth polish on the cylinder wall, and the oil consumption was 10,000-rated horsepower-hours per gallon.

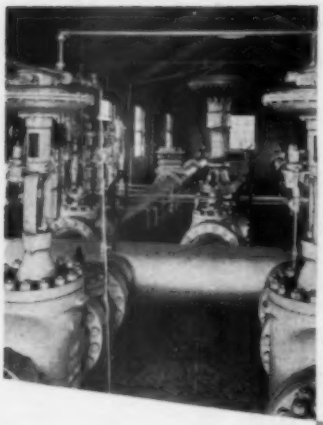
Engine No. 6 with all modifications and the 230 Brinell Hardness liners was inspected January 18, 1955, after 3000 hr of operation. Results follow:

Cyl. No.	1	2	3	4	5	6	7	8
Wear (in.)	.002	.002	.003	.002	.002	.002	.001	.003

The wear rate of .0006-in. per 1000 hr was considered good, operating performance was quiet; oil consumption was above 13,000-rated horsepower-hours per gallon of oil, and the fuel consumption for all five vapor-phase engines was averaging 8.2 cu ft per brake horsepower-hour.

Currently in the final stage of this operation, the experiment is considered entirely successful in every respect. Plans presently are to convert one of the original engines at this station to vapor-phase operation utilizing a low-pressure turbine now available for driving fans on the cooling unit or using the turbine on one of the larger units and converting it to low-pressure steam operation.

Parts 3 and 4 will appear in a subsequent issue. ★ ★ ★



Algonquin Gas Transmission Company reports:

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At the right is a view of the dispatching center of the Algonquin Gas Transmission Company in Boston. Above is shown one of the company's metering and regulating stations.

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Current Practices in Displacing Liquid Hydrocarbons from Pipe Lines

There are several methods of displacement, but none is entirely satisfactory; here's a discussion on their advantages and disadvantages

Sam C. Phelps
Chief Engineer
Interstate Oil Pipe Line Company

IN THE RELATIVE SHORT HISTORY OF the pipe line industry several thousand miles of pipe of all sizes from 2 in. to and including 16 in. have been displaced of their load of crude oil or refined products. These have been displaced for one of three basic reasons:

(1) To permit extensive external repair where severe corrosion or other physical weakness dictate that for safety or other reasons repair of the line should not be attempted with the line loaded;

(2) To permit internal cleaning (a) prior to switching to other service usually from crude oil to refined products or (b) prior to internal coating against internal corrosion attack, and

(3) To permit salvage of the pipe for reuse or sale where a pipe line has reached its physical or economical service life.

Methods and Objectives

Basic methods of displacing hydrocarbons are limited in number, however, many variations of each are employed by various pipe line companies depending on diameter, length, terrain, and numerous other factors. The mediums or substances used to displace hydrocarbons in the probable order of their magnitude are:

1. **Water.**
2. **Air.**
3. **Natural Gas.**
4. **Varsol or similar wash solutions.**
5. **Water washes with detergents or alkaline degreasing compounds.**

Before probing deeper into the mechanics of the methods and some of their advantages and disadvantages, the basic objectives of displacing the line load should be explained. The main ones are:

1. **Recover the line load for its economic value.**
2. **Prevent crop damage, water pollution, or other damage.**
3. **Prevent a potential fire and/or explosion hazard.**
4. **Prevent damage to the pipe itself.**
5. **Prepare pipe for repair or salvage.**

The line load or displacement, whether crude oil or a refined product, represents a commodity the recovery of which is usually an economic necessity. In short, small diameter field lines it is sometimes advisable to gravity drain or remove the line load by taking suction with a reciprocating pump. These usually leave some oil in the line that is eventually lost. When attempting to recover the line load, its economic value must be protected by eliminating contamination to the maximum extent. Thus, one of the major concerns in the mechanics of displacement is the prevention of contamination, especially if water is used.

When pipe lines are to be parted for repair or modification or are to be cut for take-up following displacement, any oil or oil water mixture escaping from the opened pipe line may result in immediate damage to crops, orchards, or livestock. As such drainage occurs in the lower points traversed by the pipe line route, stream, pond, or lake pollution is always a matter of concern for possible harm to fish and water fowl. Oil into water sources in irrigated areas may cause resulting crop damage many miles away.

Concurrent with concern for damage from oil contact is the equal concern for fire or explosions that are an ever present possibility whenever oil escapes from a pipe line. Pipe line personnel are trained to take care of such loose oil and their proficiency is demonstrated by the industry's safety and fire loss history.

Regardless of how much the dangers may be minimized, they cannot, from their nature, be totally eliminated. Through urban areas, through forest, grain lands, prime pasture lands, extreme precautions are taken. Wherever lives of the public or company employees are at stake or where property may be damaged, no pipe line company permits preventable loss of oil from its lines. Thus, for these first three objectives it is desirable that as near 100 per cent of the line load as possible be displaced into tankage or other pipe lines in the pipe line system.

The fourth objective of preventing

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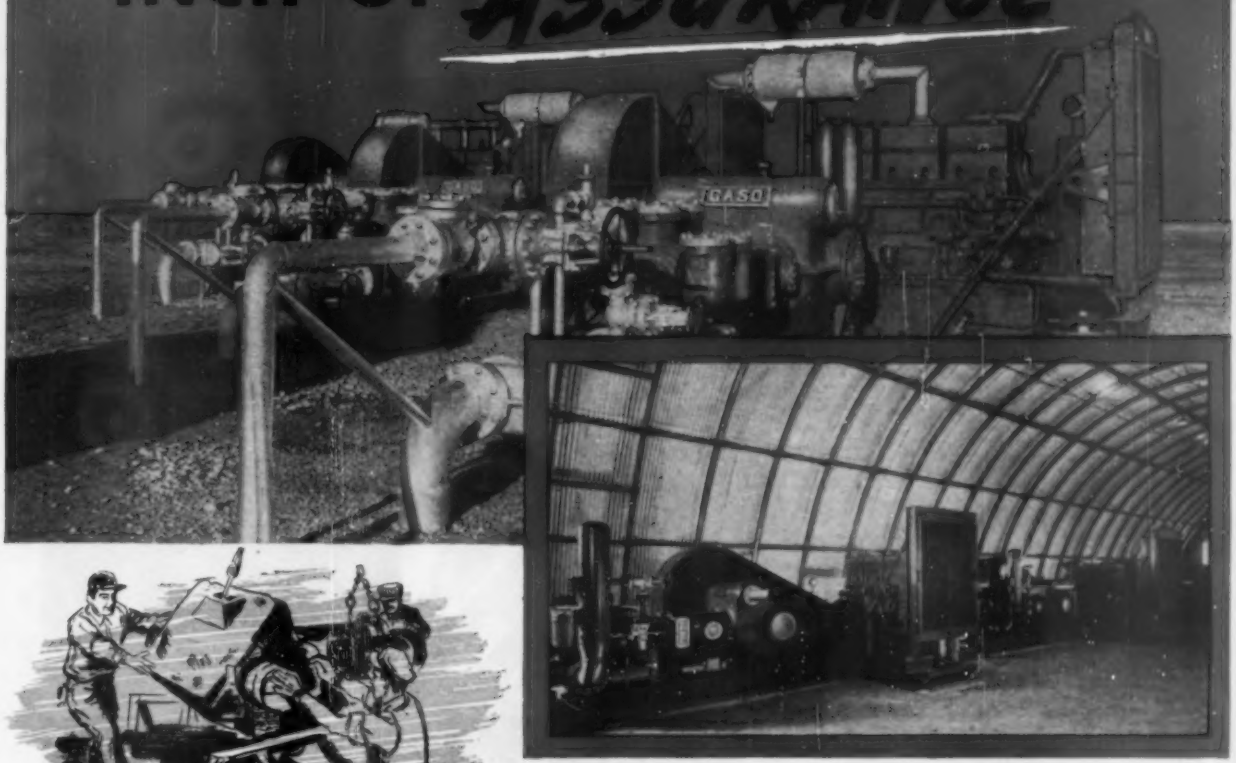

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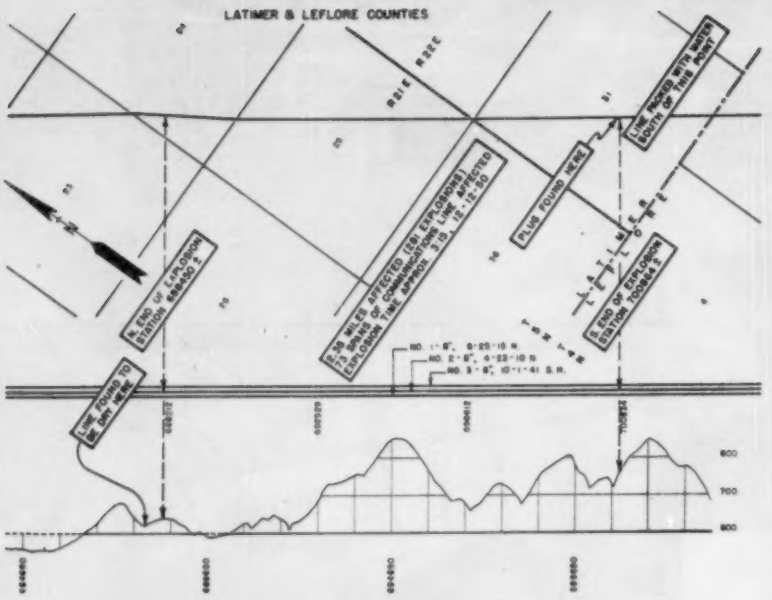
Here's what happens when an 8-in. line "explodes" during displacement . . .



Profile and detailed pertinent data on 2.35 miles of 8-in. pipe line damaged by explosion.

◆ Above, general view of damage to pipe.

◆ Above, separation plug run between air and water. Plug was not damaged.

◆ Left, another view of damaged area shows ruptures at frequent, regular intervals.

◆ Right, pipe damage. Note average interval between ruptured sections shows very well.

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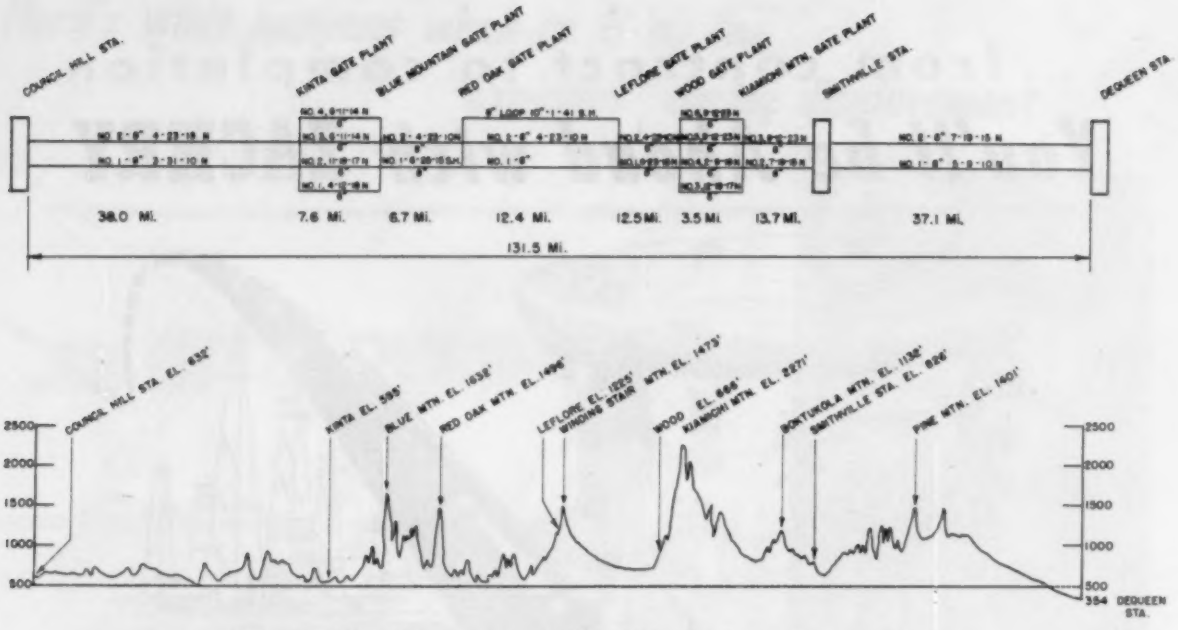


General profile and line arrangement of 6 and 8-in. pipe lines that were displaced.

damage to the pipe itself usually consists of two phases. First is usually the possible damage from freezing if water is used to displace the line. Timing operations to displace the line with water during the safe part of the year is the first simple solution. This may not always be possible. It is possible that a line displaced during the summer will remain in the ground through the following winter.

If the line has passed its physical or economic service life and is to be salvaged, other factors may dictate that it remain in place. Lack of a market for used pipe or in general for pipe of a particular size and grade, high take-up cost because of late harvest crops, ad-valorem tax rates, lack of an immediate use of the particular pipe are some of these factors.

Even if a company plans to reuse the pipe at a later date as part of its material supply, it may hesitate to expend money to take-up, haul, straighten, clean, bevel, and otherwise recondition the pipe for reuse. Lack of storage space near the take-up point, uncertainty of the geographic area where it will be used, possibility of misguessing as to the storage point and possible reshipment, as well as tying up of capital may dictate leaving the pipe in the ground for some time.

In general, most lines displaced with water except those located in an area where freezing temperatures are not expected at pipe line depths often will require displacement of the water to prevent a major risk of freezing and bursting.

Second is the possibility of inducing accelerated internal corrosion. Even the best of water available for displacing pipe lines will cause this. Contaminates present in the water usually will only increase corrosion. This will not only decrease the wall thickness and reduce its strength but will increase the inside wall roughness and decrease the flow capacity through the line if reused as line pipe. Whatever the ultimate reuse of the pipe, as well casing, as structural members, or any of the many other uses for second hand pipe, this corrosion is an economic loss.

If the line is to be left full of water, the use of an inhibitor in the displacement water might be considered advisable. The length of time the pipe is estimated to remain in the ground, its economic value, and estimated possible damage from corrosion are factors.

The fifth objective of preparing the pipe for repair or salvage usually relates to safety for repair or take-up crews and possible damage to the pipe line. If the pipe is in such poor condition from internal or external corrosion, weak threads and couplings, weak welds or other conditions that it is not considered advisable to repair it in service, most safety regulations would normally prevent hot work on the line unless it is filled with water or unless it is entirely gas free.

In general, this type of repair work is fast disappearing in most pipe line companies. Main lines operating near capacity cannot be taken out of service long enough for such work. Except for short hot spot reconditioning on stub or secondary lines and occasionally gathering lines, we do not find such major repair work being employed. The indicated extreme deteriorated condition of the pipe, the economics of a better external coating and overall cheaper cost (usually considerably less labor) of using replacement pipe have decreased the frequency of such major repair programs.

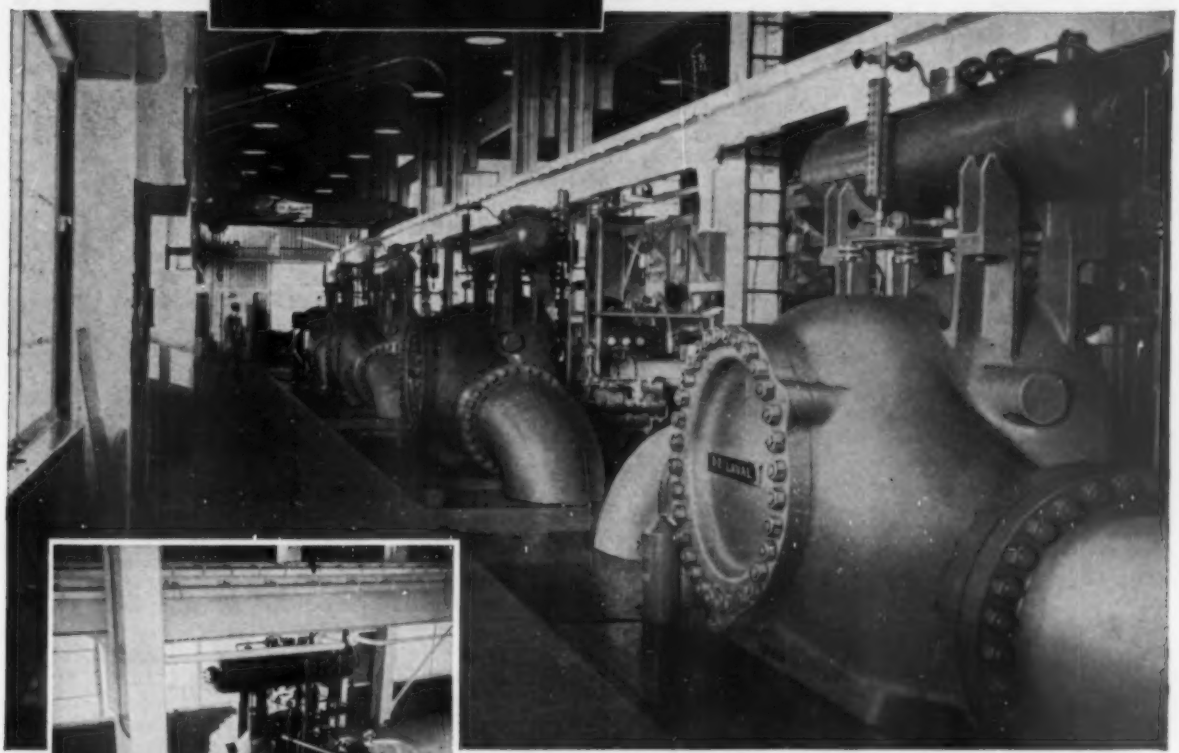
No cases are known in recent years of a major repair program extensive enough to economically justify the consideration of displacing and gas freeing a pipe line. Hence, this phase usually consists of spotting a slug of water only in the section to be repaired, cut, modified, relocated, or handled to minimize hazards of cutting, welding, and handling.

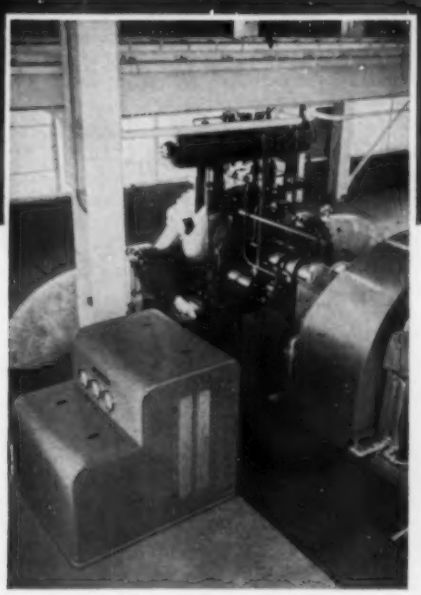
When the line is to be taken up and salvaged, some precautions for take-up must be considered in determining the means of displacement. If water is used and the line is to be taken up almost immediately, interference of the water load is of some but usually minor concern, particularly if the line is freed of all but a trace of oil. If air or gas is used the possibility and probability of a fire or explosion hazard must be determined and the procedure, if any, of detecting and removing the hazard and the procedure for cutting and take-up ascertained.

Practices In Displacing

Water displacement is perhaps the simplest and easiest method used by pipe line companies. If an ample supply of water is available or can be ac-

FOUR DE LAVAL CENTRIFUGAL COMPRESSORS *in Tescott, Kansas station of Northern Natural Gas*





For easy installation, De Laval pipeline compressors are designed in two packages: (1) The machine plus the emergency seal tank, (2) The auxiliary console which contains the filters, pumps, coolers and other accessories.

Here's more proof of the efficiency and dependability of De Laval centrifugal compressors for high pressure gas transmission. This Tescott, Kansas station of the Northern Natural Gas Co. has four De Laval centrifugal compressors in series.

The station flow is 930 M^2SCFD, station inlet pressure 477 psig and discharge pressure 745 psig. *By changing the impeller and a few minor parts, these units can handle 1,100 to 1,200 M^2SCFD.* Three identical De Laval compressors are on the job in the Macksville, Kansas station of Northern Natural.

De Laval centrifugal compressors offer important engineering features. • Pressure contact shaft seal eliminates gas leakage. • Construction is heavy and rigid throughout. • Units have high load carrying capacity. De Laval units, totaling more than 200,000 hp, are now in operation on major pipelines.

DE LAVAL *Centrifugal Compressors*

DE LAVAL STEAM TURBINE COMPANY

869 Nottingham Way, Trenton 2, New Jersey

DLSCC

cumulated, full displacement with water is usually made. If water is scarce, a slug only may be used. Full displacement has the advantage of using any displacement rate desired and any pressure required to overcome static and friction heads encountered, limited only by pump capacity and head. If sufficient pump capacity is not available in a regular pump station, most companies have sufficient portable equipment that can be set for temporary use at any point desired.

A batching type plug consisting of a series of rubber cups on a mandrel but without the brushes or knives commonly associated with pipe line pigs is run between the oil and water. Multiple plugs have been run together; however, no benefits can be attributed to this according to our experience. The present day commercial plug with 3 or 4 rubber cups is an effective separator of oil and water under most conditions and effectively minimizes contamination of the oil being displaced.

Displacement rate is usually very close to the usual pumping rate through the line, especially when an existing pump station can be used to pump the water. When portable equipment must be used or for other reasons a slower rate is used, however, it is desirable to keep flow rates in the turbulent range if possible. Most displacement rates are from 2-5 ft. per sec.

When multiple lines or loops along a line are to be displaced, contamination must be watched closely. No overall procedure can be given as each case must be analyzed individually. Normally, but not always, it is better to displace each parallel line or loop separately. If displaced simultaneously, some variation in length or flow rate will cause different arrival times at the end of the loop or parallel line. It is often impractical to establish the required sampling procedure at such points and often impossible to shut off or pinch the flow in one line should the water reach the point in it ahead of the other line. Leaking valves in crossovers or other manifolding at such points may cause unexpected contamination, particularly if parallel lines or loops are displaced separately.

At points where water is to be stopped, diverted, or stored, adequate sampling will be required even though a batching plug is used. This may be adequate hand sampling and testing equipment and personnel, automatic sampling of many types, recording gravitometers, dielectric constant detectors of one of several types or possible other instrumentation. A detector to indicate the batching plugs' arrival is desirable but not absolutely essential. Designated steel tankage, tank fire dikes or ponds for catching the water will be essential in almost all cases.

As the volume and percentage of contamination will not be known for sure ahead of time, some evaluation will have to be made of the interface mix. The volume of contaminated product may justify treating to separate the water and oil to permit recovery of the bulk of the oil before disposal. In any event, settling, skimming, or other separation will usually be required before dumping the water to waste to prevent pollution and incurring damage.

An old fire dike from which a tank had been removed and a temporary pond have been used to advantage to catch the interface mix. The amount of oil did not justify any attempt at recovery, however, a properly installed drain in one case and a siphon in another permitted release of the bulk of the water, followed by controlled burning of the oil after which the remainder of the water was released. Piping arrangements must be planned in advance for handling the interface and temporary lines installed if needed.

Although in some cases, in arid sections only, a small slug of water has been used to displace oil from a line, the water must be moved with air or natural gas with all attendant advantages and disadvantages of their use as described later; hence, no advantage is seen for the use of a small slug of water. Two separation plugs would normally be used, one at the head and one at the tail of the water slug. No less contamination, no less oil left in the line, and no reduced hazards can be anticipated than if air or natural gas is used to displace oil directly. Diversion and handling of the water slug on the final receiving end has all the problems and in essentially the same magnitude as if water displacement is entirely by water.

Disadvantages of Water

The major disadvantage of water is that its use is restricted to the period of the year when freezing will not occur and it cannot be left in lines during the winter in many areas where lines may be displaced.

The second disadvantage is in its disposal at the final receiving point and at intermediate points if the line is taken up without displacing the water. Normally, the trace of oil found along the line is too small to cause any damage. Its presence must be anticipated at all times and, when found, the amount determined. Large amounts must be impounded before spreading and picked up in tank trucks if economics warrant. Burning requires certain safety precaution and must be restricted in some areas and prohibited in other areas. The presence of only a trace of oil in some cases may cause a major disposal problem.

The third disadvantage is the repetition of cost if the water must be displaced by some other means. This extra cost is one factor that makes other methods very attractive in some cases.

The fourth disadvantage is the somewhat unexpected hazard in displacing the water. This is based on displacing the water with air. It is assumed that if natural gas, nitrogen, carbon dioxide, or other gas is contemplated that the oil would be displaced with it directly without the intermediate use of water.

At least one serious explosion occurred within a pipe line while displacing water with air. The oil in the line had been displaced with water using batching or separation plugs. A total of 44.4 miles of 6 in. and 253.2 miles of 8 in. were displaced. The 6 in. was in four parallel lines in two sections, one 3.5 miles long and one 7.6 miles long. The 8 in. was in double parallel lines for 108 miles and three parallel lines for 12.4 miles. The total right-of-way distance was 131.5 miles. Scrapers had been run through all lines regularly and the oil was displaced without any scrapers hanging or other difficulties. The oil was displaced from the south end to the north, which was the regular flow direction. The parallel lines were displaced separately; however, pump capacity was reduced so that flow rates were very near normal for the usual operating conditions. The terrain traversed was very mountainous and rough.

After displacing the oil, two 107-cfm 500-psi compressors were set at a junction point of parallel 8-in. and four 6-in. lines some 38 miles south of the north end of the section displaced. Water from both 8-in. lines was displaced from this point to the north. Then the four 6-in. lines to the south were displaced. While displacing one of the 8-in. lines to the south of the 6-in. lines, a violent explosion ripped through 2.35 miles of the 8 in. As was the practice in all cases, a 4-rubber cup separation plug was being run between the water and air. Although there were no actual eye witnesses, from all evidence it is almost certain that the explosion started at the plug and moved backwards or to the north. It should be remembered that this displacement operation was counter to the flow of oil and the flow of water displacement. It is estimated that some 41,000 bbl of water had passed this point in displacing all of the pipe to the north. This water had had no detergent or cleaner added.

FIVE OUT OF SEVEN pipeline contractors on the 561-mile Transco 30″-36″ superinch line use Cleveland Trenchers. On this big job of oversize trench for Transco, these Cleveland 320's consistently produced high daily footage—day in and day out. Because of their outstanding maneuverability and versatility, these same "320's" are also employed efficiently and profitably on smaller diameter pipelines—paying *extra* dividends on the equipment investment.
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It is perhaps surprising to some that enough oil would remain pocketed or clinging to the pipe wall to form an explosive mixture after all the water and plugs that had passed this section, however, its existence is unquestioned: The source of ignition was never determined for sure and is probably of little consequence as several sources were possible and one or more would always be present. In this case the possibilities were:

1. Heat generated by the oxidation of iron sulfide or other sulfur compound left in the line by past operation. The fact that the plug was being run counter to past direction of flow and scraper runs might increase the possibility of flipping or turning a piece of iron sulfide scale and exposing an unoxidized surface. Such a piece might have been lodged in the recess in one of the screw couplings.

2. Spark caused by a mechanical means such as rock or pieces of steel lost from scrapers run at some previous date. An old scraper blade was found near the plug after the explosion.

3. Spark from a static electricity discharge, the charge having been built up on the metal core of the rubber disk plug or having been generated by agitation of water by-passing the plug.

4. Heat generated by compression from a source other than the mechanical means used to compress the air for displacing purposes, such as an unexplainable pressure surge.

The latter two are remote possibilities. The pressure at the point of the plug was less than 200 psi. No surging is probable as an employee was bleeding water at a tap approximately one mile south of the plug and no pulsating or surging was noted in the stream being bled off at any time. There was also no evidence of a surge on the recording pressure gage at the compressors, which were operating at 210 psi at the time of the explosion.

Use of Compressed Air

Compressed air has been used to displace many miles of pipe line using a separation plug between the air and oil. There is a serious mechanical limitation to this method, as most portable compressors readily available are limited to 150 psi or less, hence, in displacing lines with major variations in gradient or long lines where the friction head may be high, the displacement rate may be restricted at least. This may be partially overcome by using portable pumps to relay the oil stream ahead of the plug. This requires block valves and connections for suction and discharge lines. Installation of valves, lines, and pumping units, as well as operation of the pumping units, add to the cost. The attendant fire and explosion hazard is greater than that reviewed previously. At least one case is known where 32 miles of 10-in. pipe was blown up using this method. Exact details are not known by the writer. It is reported that in this case the air pressure was approximately 100 psi. The probable sources of ignition are the same as mentioned above. As mentioned, some companies use a small (50-200 bbl) slug of water between the air and oil; however, the washing and cleaning action probably has little to do with reducing the hazard and adds a disposal problem at the end point. Thus, this method has two principal disadvantages and little in the way of advantage.

Displacing With Gas

Natural gas has been used somewhat limitedly the past few years in displacing liquid hydrocarbons. This is due largely to limited availability at the desired location. It may be anticipated that use of this method may increase particularly in the United States as more gas lines are laid increasing its availability. The principal objective is to exclude air from the line to eliminate the explosion hazard.

This method requires that the gas supply be available reasonably close to the pipe line being displaced. Sufficient pressure to overcome elevation and friction heads of the displaced stream is desirable; however, portable compressors may be used to boost pressure if warranted. By-passing of the separation plug by the gas should be small with available commercial plugs and would not be objectionable or dangerous unless sufficient gas bypassed to cause vapor lock of the line or to cause damage to the receiving tank. With pressure gages and meters, the volume of gas entering the line can be accurately measured and controlled and the rate of displacement similarly controlled and estimated with reasonable accuracy.

The line should be packed and full of liquid hydrocarbon before using the natural gas method. If the line has been partially drained and air pockets may be present, a dangerous mixture may result. Gas may not be available for this purpose during winter months when domestic demands are high and certainly would not be in most cases during winter storm periods. Should a separation plug hang, additional hazards exist if it becomes necessary to tap the line in an attempt to dislodge the scraper or cut the line to remove the hung plug. Special precautions must be taken and an expensive loss of gas may occur if a long section must be bled down before cutting. Serious hazards still exist when cutting the line for take-up from the standpoint of fires and explosions.

★ ★ ★

A network of 186,723 miles of petroleum pipe line crisscrosses 44 states and the District of Columbia. Pipe lines are the third largest ton-mile movers of all forms of commodity transport.

Water Soluble Cleaners

Some consideration has been given to the use of Varsol and water soluble cleaners such as various detergents and some of the alkaline degreasing compounds. To the best of the writer's knowledge, they have been used in a limited way in cleaning pipe lines that are to be internally coated with a plastic lining in place against internal corrosion. This is with the objective of removing the oil and/or paraffin film to permit adherence of the coating primarily and removal of the oil film to reduce fire or explosion hazard secondarily. Cost of material, mixing, and injection are drawbacks to the use of such material in a major displacement project.

Conclusions

The only clear cut conclusion appears to be the fact that the pipe line industry does not have the final solution to the problem of displacing a pipe line at this time. The three major methods using water, air, and gas have serious disadvantages under various conditions. Neither of the three leaves the displaced pipe in an entirely safe condition for salvage. Water is the safest, particularly if it does not have to be displaced prior to take-up. Danger of damage from freezing is its major disadvantage.

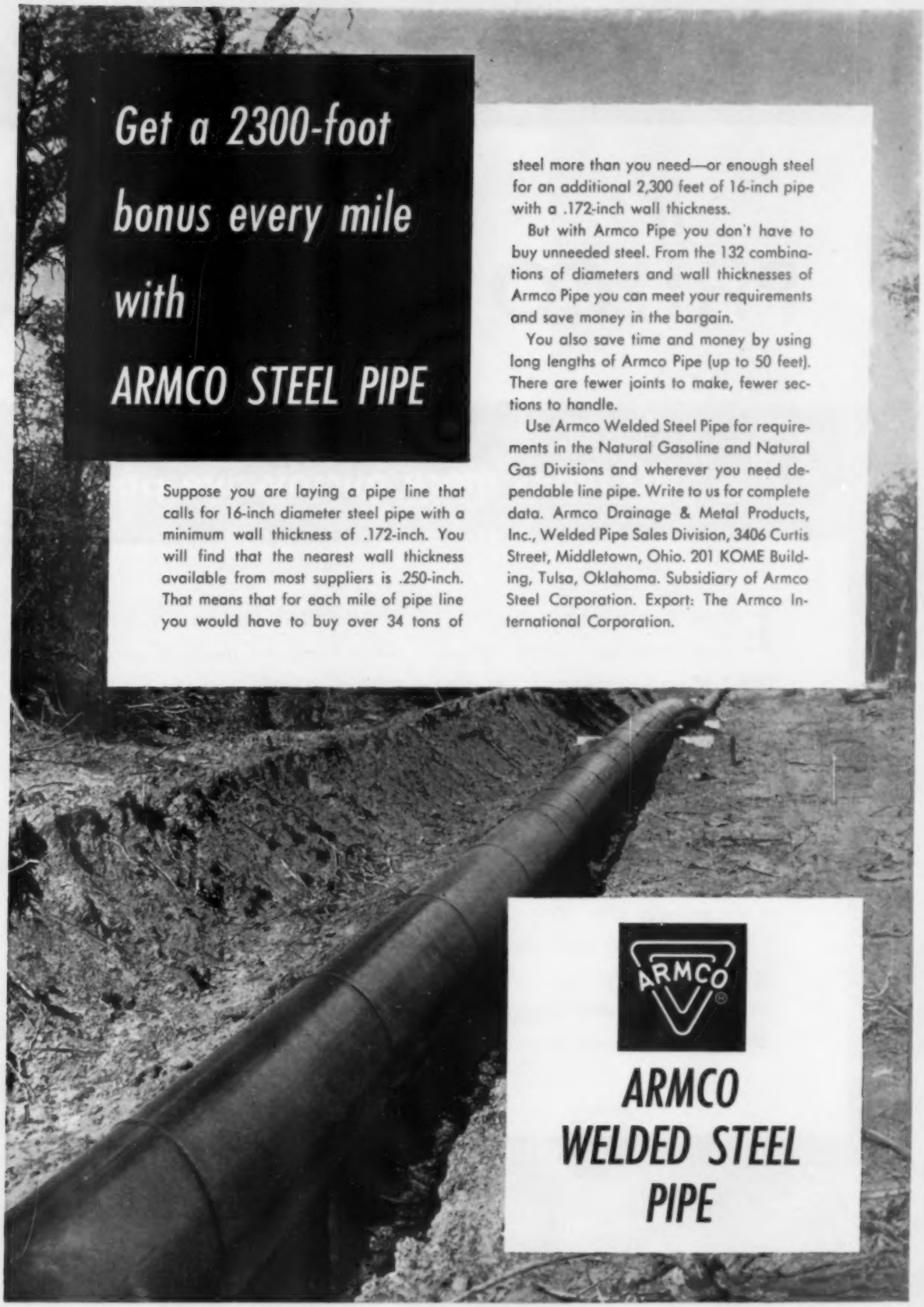
Use of air, in general, is the most dangerous of all methods. Use of natural gas is safe if properly handled during the actual displacement but may be expensive. After the liquid is displaced, the gas cannot be disposed of in such a way that leaves a very safe line.

Batches of Varsol and water soluble degreasing compounds have been used in a limited way and all checking of samples done to date has shown a safe gas-free atmosphere in the pipe. Use of these is slow and expensive.

Many discussions have been held on the possible use of nitrogen or carbon dioxide or other non-flammable gas; however, to the writer's knowledge none has been tried. Cost and use problems detract from their probable use.

Acknowledgment

Presented at the ASME Petroleum Mechanical Engineering Conference, New Orleans, Louisiana. ★ ★ ★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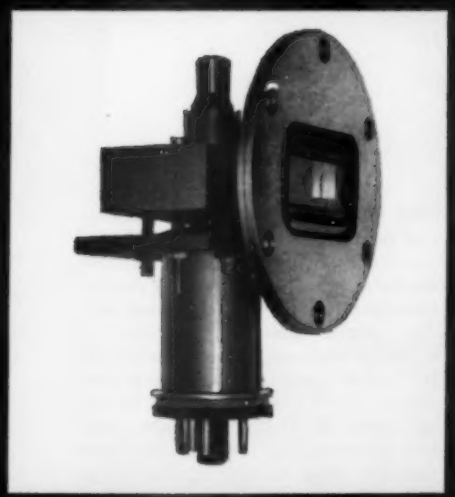

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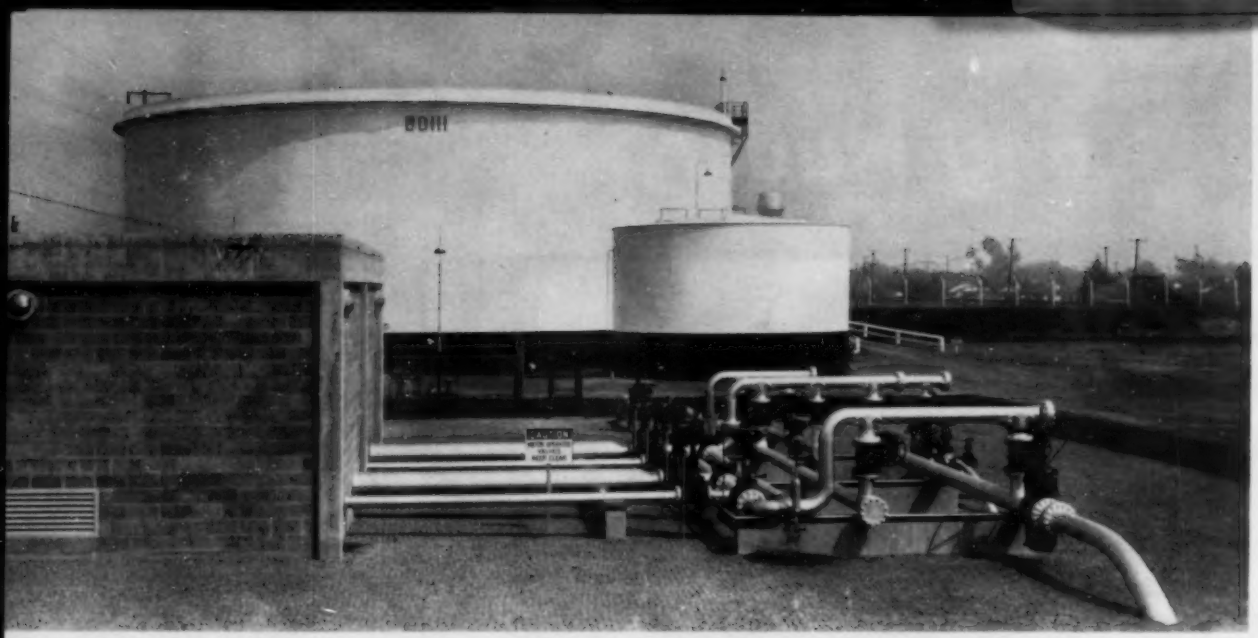


General view of station showing motor-operated valves and switching manifold.

P 615.5

EXCLUSIVE

Union Oil's Norwalk station is remotely controlled and has

Latest in Automatic Control

Jerry Stumm
West Coast Editor

REPLACING AN OLD STEAM PLANT built in 1916, Union Oil Company of California has placed in operation a new, remote controlled, completely automatic pump station at Norwalk, California. The new booster station is located on a 10-in. line moving crude from the East Los Angeles basin area, originating at Stewart Station, to tankage at the company's refinery at Wilmington, a distance of 26 miles.

Ehrhart & Associates, of Los Angeles and San Francisco, was the general contractor for the design and construction of the new station.

Pumping and Control

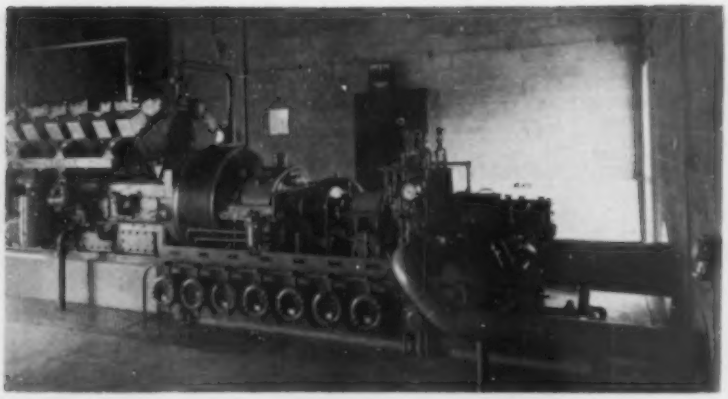
The station is powered by two 300-hp internal-combustion, V-12 gas engines, with a maximum engine speed of 1000 rpm. They are coupled by Fawick clutches to centrifugal pumps driven through speed-increaser gears, which step up the pump speed to a maximum of 3900 rpm. The pumps are compounded, giving a maximum discharge pressure of 600 psi, and a maximum daily throughput of 50,000 bbl.

The booster station is controlled during pumping operations by a suction and discharge pressure controller that automatically maintains 30 psi station suction pressure by throttling the station's outgoing stream. The discharge section of the controller has an overriding control feature that takes over should the discharge pressure exceed 600 psi which further throttles and limits the pressure to that figure.

During the operation of the suction-discharge pressure controller, the engine operates as a constant speed unit. The engine governor, however, is equipped with a diaphragm speed control that is operated by a separate controller. This controller receives its signal from the suction-discharge pressure controller and varies the engine speed in order to hold the diaphragm valve open on the station discharge.

Line switching operations, and station start-up and shut-down, are remotely controlled and indicated on a panel at Union's Stewart pump station located near the city of Brea, about 12 miles upstream from Norwalk.

Remote control panel at Stewart station.



Mainline pumping unit. High temperature switches mounted on rack, foreground.

Manifolding consists of a system of motor-operated valves that are also remotely controlled from Stewart Station.

Waste Water Disposal

The main line from Stewart to Norwalk, besides being used for shipment of oil, is also used for movement of waste water produced with the oil from wells in the area. This waste water is moved into Norwalk for final separation and disposal into the Los Angeles County water disposal system.

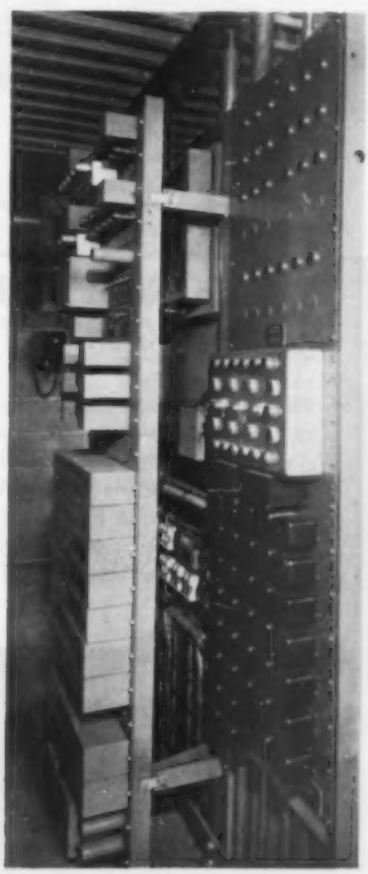
A periodic shipment of water is received from Stewart tank farm in a storage tank at Norwalk, using a 3-way transflow plug cock. An enniscope water indicator is installed on the suction line at Norwalk and sends a signal to the Stewart console to indicate the arrival of oil or water interface. The Stewart operator positions the 3-way valve from this signal to receive water in the tank, or switches the oil back into the line for shipment to Wilmington.

Engine Control

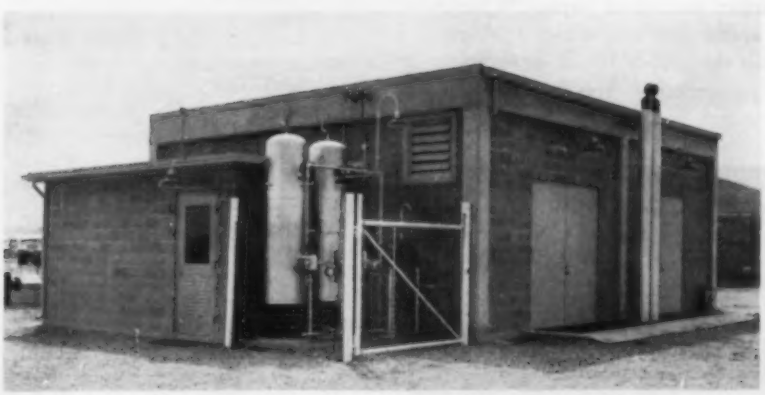
Supervisory control, supplied by Control Corporation, uses a telephone carrier channel for the transmission of supervisory information, as well as

Control center power panel at Norwalk station.

Engine control panel on foreground rack and supervisory control equipment on rack to left.



Rear view of Norwalk station. Concrete block construction of building, and hospital type mufflers (in trenches below double doors at right) minimize noise.



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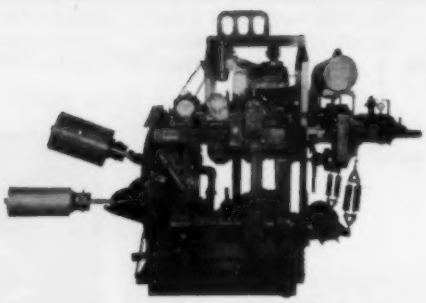

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for continuously telemetering suction and discharge pressure. All functions not directly connected with engine operation are controlled by the supervisory control. Engine operation is controlled by a special engine control.

The engine control panel, manufactured by C & B Manufacturing Company of Los Angeles, was designed for standard, relay, rack mounting, and is equipped with hermetically sealed plug-in type relays. The panel was designed to receive commands from the supervisory control for engine starting, loading, running, and stopping.

Actual function of the panel, after it has received the starting command from the supervisory control, is as follows:

Motorized suction and discharge valves move to open position and the blowers in the engine room vents start.

After the valves have completed their opening, interlocked limit switches allow the engines to commence their starting cycles, consisting of five "on" cycles of 10 sec and five "off" cycles of 10 sec.

Cranking is accomplished by the opening of a solenoid valve, which allows air to enter the cranking engine. Failure of any sequence will be immediately indicated on the panel.

After the engine has been started, the governor brings the engine to the idling speed, where it runs during the engine warm-up period.

When the engine jacket water reaches a pre-set temperature, a light on the supervisory panel (at Stewart Station) lights up to indicate that the engine is ready to load.

The operator then pushes the load button to put the engine on the line. The circuit that controls the engine load opens a solenoid valve, which admits air to the air clutch.

At this time, the engine governor has air admitted to it and brings the engine on the line, which is indicated on the main panel.

A button is provided on the supervisory panel at Stewart Station to disengage the clutch, which brings the engine automatically to an idling speed.

An additional button is provided on the supervisory control panel to stop the engines.

After the engines have stopped, the fuel gas and pump suction and discharge valves are automatically closed, which is also indicated on the main control panel.

The entire system is fail-safe for all normal malfunctions, and any such malfunctions or failures that might occur are clearly indicated on the panel.

* * *

(Below) Wheel-type 150 Trenchliner® opens cross-country trench at the rate of 25 feet per minute. Digs 16 to 26 inches wide, 5 feet-9 inches deep. Has standard crawlers with 16-inch grouser-type shoes (street pads optional). 12-inch smooth treads also available. Choice of standard-make gas or diesel engine. Parsons line also includes 3 ladder-type Trenchliners on crawlers.

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GAS INDUSTRY FORESEES

record gains in 1956

Dean H. Mitchell, President, American Gas Association

THE past year was one of the most successful in the history of the gas utility and pipe line industry. During 1955 the industry reached new record high in numbers of customers served with utility gas, in volume of gas sold to ultimate consumers, and in revenues received from the sale of gas.

Reserves of natural gas at the beginning of 1955 were at an all-time high, despite a new record production figure in 1954. The industry added more than 1,000,000 new customers during 1955.

Natural gas systems are continuing to spread into new areas and to augment supplies in residential and industrial areas now served. With the completion of the Pacific Northwest pipe line, only two states in the nation will not be receiving natural gas. Expanded use of underground storage is making it possible to serve more customers with a minimum increase in distribution facilities.

After a careful review of the present record figures and the factors that were responsible for the successful achievements of 1955, most members of the American Gas Association predict another record year in 1956. There is an almost unanimous belief among gas utility and pipe line companies that new records will be established in all areas of gas service next year.

Under approval of the Federal Power Commission about 4500 miles of new natural gas transmission pipe line were authorized last year. More than 3000 miles of transmission line actually were laid with the remaining 1500 miles under way at the year-end.

More than 22,000 miles of natural gas distribution and storage pipe line, not requiring FPC approval, were constructed during the year. Today, the total of natural gas gathering, transmission, distribution and storage pipe lines in the United States is more than 445,000 miles. With an additional 50, 000 miles of pipe line carrying manufactured and mixed gas, the nation's entire gas pipe line now is approaching one-half million miles, and will pass the 500,000-mile mark in 1956.

Gas utility and pipe line companies spent approximately $1.385 billion for new construction and expansion of facilities during 1955. The industry expected to spend an additional $1.205 billion for each construction in 1956. Estimates made by AGA Bureau of Statistics place total construction expenditures for the four years from 1955 through 1958 at more than $4.3 billion. The gas industry now has nearly $16 billion in gross assets and is well on its way to becoming a $20 billion industry.

Review and Forecast

At the end of 1955, the gas utility industry was serving about 29,210,000 customers, including about 243,000 LP-gas customers served directly by gas utility companies. This was a gain of about 1,056,000 customers or an increase of 3.8 per cent over 1954, when the industry was serving about 28,154,000 residential, commercial, industrial, and other customers. There were approximately 7,500,000 customers served with LP-gas in areas not on gas utility mains. The total of nearly 29 million straight utility gas customers was a new record, as was the total for all gas customers.

More than 24,000,000 customers were receiving natural gas at the year-end, a gain of almost 2,000,000 customers, and an increase of 8.4 per cent over the 22,159,000 natural gas customers served at the end of 1954. Manufactured and mixed gas customers decreased to less than 5,000,000 customers, a decline of 14 per cent, as additional companies converted to use of straight natural gas.

The gas utility industry sold approximately 66,500 million therms of gas during 1955, a new record volume. This was a gain of 8.2 per cent over the 61,428 million therms sold in 1054.

Natural gas sales achieved a new high of 62,908,000,000 therms, up 8.4 per cent over the 58,000 million therms sold a year earlier. Manufactured and mixed gas sales totaled about 3,464 million therms, an increase of 3.9 per cent over the previous year's volume.

Revenues from utility sales of gas nearly reached the 3½ billion mark, in achieving a new record total of $3,473 million, a gain of 13.8 per cent over $3,052 million, a previous record high established in 1954. Natural gas revenues increased 16.2 per cent to total $2,995 million, also an all-time high. Manufactured and mixed gas revenues were about $458,000,000, up 0.4 per cent over the previous year's total.

Pipe Lines and Reserves

Full certification was granted during the year by the FPC for the construction of the American-Louisiana Pipeline Company's 1200-mile line from Texas to Michigan and for the 1800 mile line of the Pacific Northwest Pipeline Company from the San Juan Basin to the northwestern states. Both of these lines are well under way. The position of the Pacific Northwest Company has been greatly strengthened by the recent decision of the Federal Power Commission authorizing the importing of Canadian gas. The West Coast Transmission Company now will construct its line bringing Pacific Northwest additional supplies of natural gas from the Peace River fields. Several major transmission lines completed extensive looping and paralleling lines during 1955.

Underground storage operations increased substantially during the year ending December 31, 1954. At the start of 1955 there were 172 underground storage pools in 17 states and an additional 12 pools were under construction. These active pools had an ultimate capacity of 1859 billion cubic feet.

There are 6395 active storage wells in operation in the 172 pools. It is estimated that the 12 pools under construction would add nearly 200,000 million cubic feet of storage space for underground storage of natural gas. With new gas househeating customers estimated to be added for the next few years at a rate of about 1,200,000 per year, underground storage of gas becomes an increasing important factor in stabilizing the gas load.

The gas industry spent nearly $75, 000,000 on construction of underground storage facilities in 1955 and will spend nearly $50,000,000 on such facilities in 1956. It has been estimated that about $187,000,000 will be spent on underground storage construction in the years 1955 through 1958.

Proved recoverable reserves of natural gas at the beginning of 1955 had reached a new high level of 211.7 trillion cubic feet, an increase of about 263 billion cubic feet over reserves at the beginning of 1954. Production of natural gas in 1954 reached a new peak of 9.4 trillion cubic feet, but new discoveries and extensions of revisions of previous estimates more than offset this tremendous use of natural gas.

* * *

Digging the pipeline trench was one of the toughest equipment assignments which many of the men on the spread had ever seen. Between 40 and 50% of the ditch was dug in rock.

The deep grousers on tractor-type treads of the 22-B provide the bite and traction to climb grades easily. These treads also raise ground clearance to 20¾-in.—high enough to clear rocks and other obstructions along the right-of-way.

Pushing Pipe Over The Continental Divide

Laying a 30-in. gas line over a 7,000-ft. mountain in winter temperatures as low as 10° below zero is a job for experienced men and tough machines. R. H. Fulton and Co. had plenty of both when they tackled a 252-mile assignment on the leg between Corona and Gallup, N. Mexico.

Eight Bucyrus-Erie 22-B dragshovels were used for trenching. These machines turned in remarkable endurance records, working on steep and rocky terrain. The total excavation ran about 3½ million yards, most of it blasted malapai, broken limestone and varying sandy soils. Spread Supt. Boyd was particularly pleased with the high percentage of operating time of the 22-B's — 92 per cent.

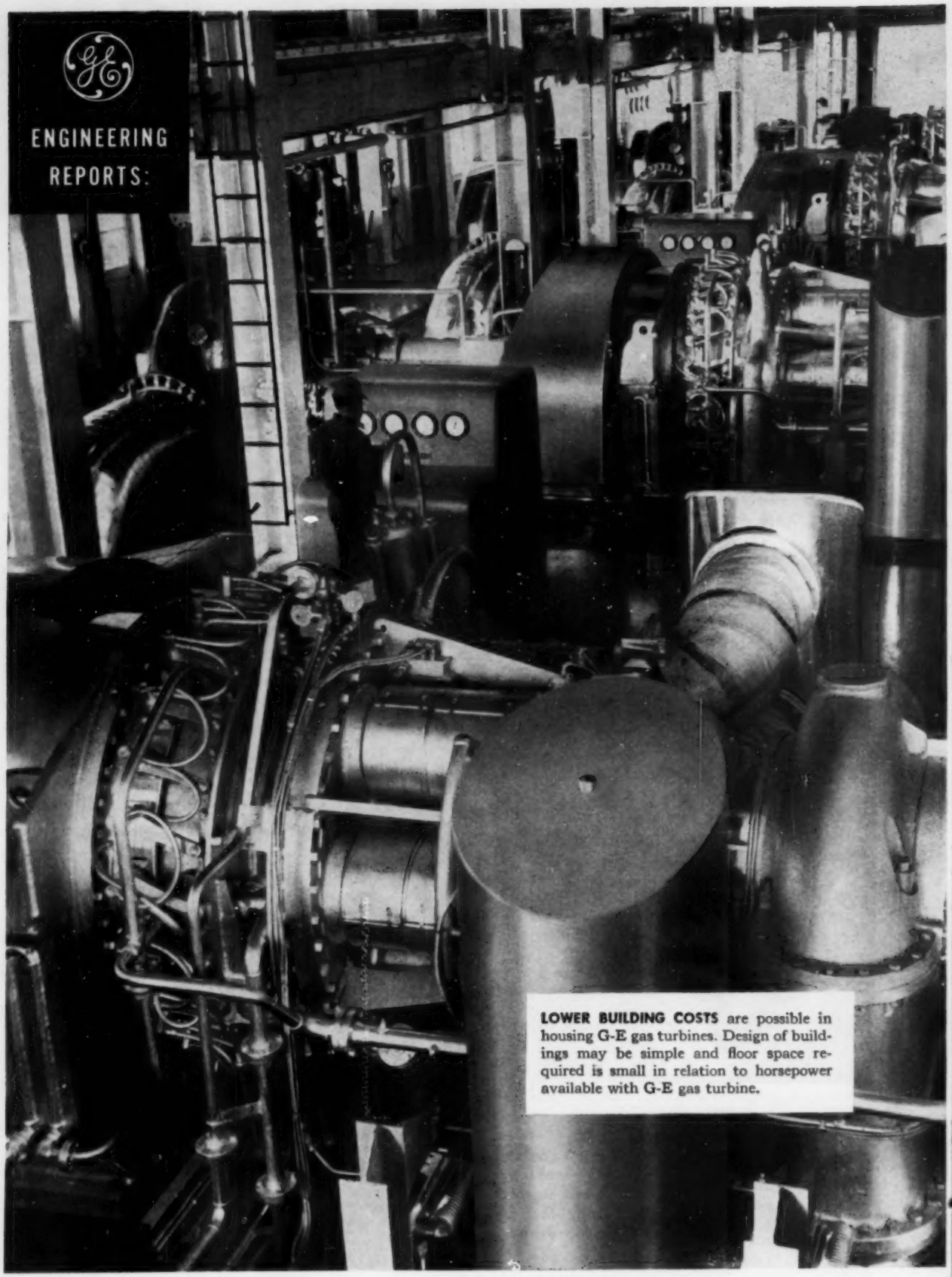
Other Bucyrus-Erie equipment on this job included a 15-B and 22-B clamshell and a 22-B Transit Crane.

Bucyrus-Erie excavators with tractor-type treads can bring time- and cost-cutting performance to your pipeline jobs. See your Bucyrus-Erie distributor for all details.

11BE55

BUCYRUS ERIE

South Milwaukee, Wisconsin


ENGINEERING
REPORTS:
LOWER BUILDING COSTS are possible in housing G-E gas turbines. Design of buildings may be simple and floor space required is small in relation to horsepower available with G-E gas turbine.

41 G-E GAS TURBINES now operating in gas pipeline industry have proved to be economical power sources.

8 G-E gas turbines for Northern Natural Gas give up to

25% MORE HP FOR PEAK LOADS

A total of eight 5700-hp General Electric gas turbines are now in operation at the Tescott and Macksville compressor stations of Northern Natural Gas Company in Kansas.

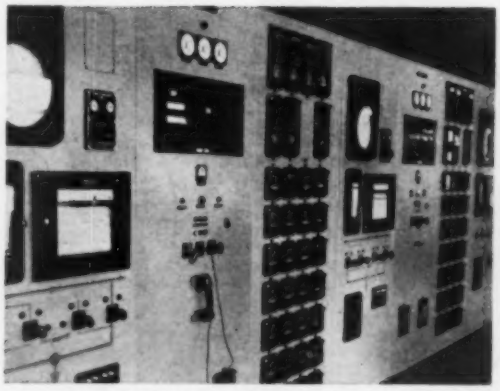
These complete, economical prime movers have this fundamental characteristic: horsepower increases as ambient temperature decreases. Thus, during cold weather, when demand is greatest, up to 25% more power may be delivered.

Proven economies of operation and maintenance explain why many natural gas pipeline stations are being planned for G-E gas turbines. Have you investigated their many advantages?

For more information, contact your nearest G-E Apparatus Sales representative, or write for information bulletin GEA-5962 to General Electric Company, Section 661–52, Schenectady 5, New York.

Combustion Gas Turbines for the Gas Pipeline Industry—Backed by over 50 years of Turbine Leadership

GENERAL ELECTRIC



COMPLETE STATION CONTROL is handled from the four combined process-control and turbine-control panels. After preliminary manual operations, turbine comes to speed automatically.

COMPACT, FACTORY-ASSEMBLED, low-voltage switchgear, Cabinetrol* panel at Tescott station were planned by General Electric to take a minimum of space and to meet the station's individual requirements.

*Registered trade-mark, General Electric Co.

Closeup of the 54-in. blind flange which is 1 ¼-in. thick, with the 54 to 48-in. reducing nipple welded to it. Nipple has a slip-on flange. Note Concrete mat and supporting saddles constructed to carry the big valve. At right, 48-in., 150-lb gate valve being lowered into place.

P 615.63

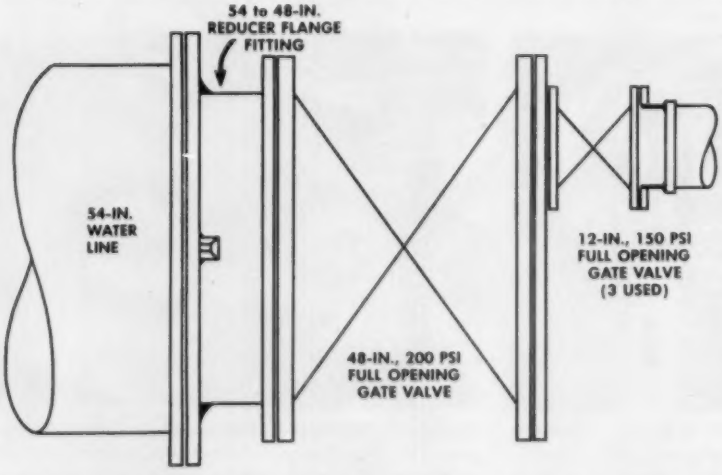
Nine "little" taps make ONE BIG TAP

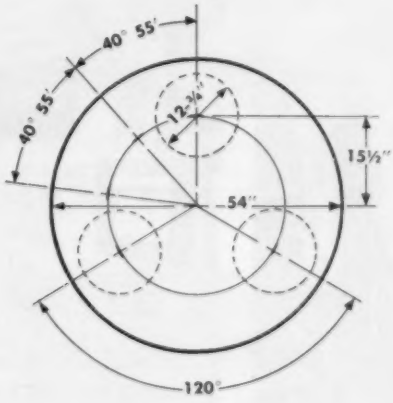
Jim Ford
Tod Pazdral Pipeline Specialties
Houston, Texas

EXCLUSIVE

ONE of the most unusual "hot tap" jobs ever attempted was completed recently at Pasadena, Texas. When the city of Houston's industrial water supply line was constructed under the Houston ship channel and through the industrial area at Pasadena last year, a flanged cross was installed with one 54-in. branch facing east for a future line. Phillips Chemical Company and Shell Oil Company completed plans to utilize this branch connection, and lay a line to their plants at Pasadena and Deer Park.

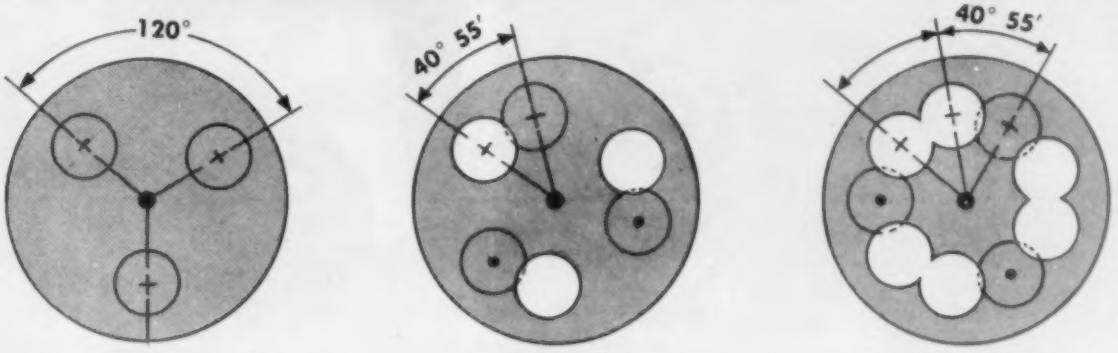
Because the existing trunk line was operating at about 60 psi pressure, and could not be taken out of service to connect the new proposed line, it was





Schematic diagram, left, shows how reducing nipple was attached to 54-in. blind flange, location of big valve, and location of template flange with three 12-in. valves. Diagram (right) shows size of "cuts" and template positioning.

Nine little taps make ONE BIG TAP



FIRST POSITION SECOND POSITION THIRD POSITION

How the cuts were made. Template flange was set in first position, and tapping machine was inserted in each of the three small valves and cuts made. Big valve was then closed, template flange was rotated to second position, and three more cuts made. Same procedure was used for third position. Star-shaped center coupon was recovered by retaining rod attached to collar welded previously to center of the 54-in. blind flange.

necessary to find some way of making the new connection under pressure.

Engineers of T. D. Williamson, Inc., Tulsa, Oklahoma, and Tod Pazdral Pipeline Specialties, Houston, working with Phillips Chemical Company, devised a method of tapping the 54-in. blind flange on the branch, through a 48-in. valve.

Although a single 24-in. diameter cut could be made using the largest standard tapping machine available, it was decided that a large cut would be needed in order not to restrict flow into the proposed new line. Plans were then made to make a series of nine 12-in. diameted overlapping cuts that would result in a hole with a scalloped circumference, but with a diameter of 43-in.

A 48-in., 150-lb gate valve was to be permanently installed at the take off point as a block valve, and also to be used as a cut off valve for the tapping operations.

To open this valve required 512 revolutions of the hand wheel. In order to save the valuable time and man power that would be required to perform this opening and closing nine different times, the template flange used to mount the tapping machine was designed to have three 12-in. gate valves that could be opened and closed with each cut.

A pipe fitter's "mule" was rigged to the 48-in. valve, saving lots of "muscle-power" and time for even the few times that it was necessary to open and close this big valve.

By having three tapping holes in the template flange spaced at 120 deg, it was necessary to rotate the flange only twice from its original position on the big 48-in. valve.

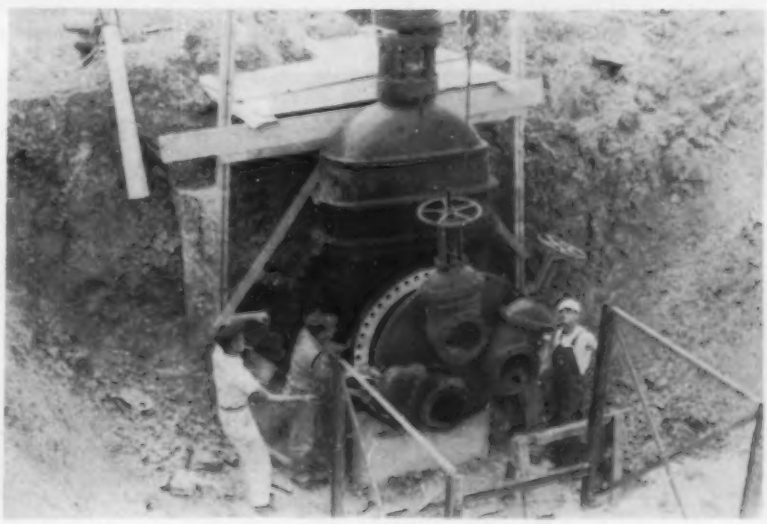
Another major consideration was the problem of retaining the star shaped center coupon of the flange. To do this, it was decided to use a 1½-in. polished steel retaining rod, threaded to fit into a 3-in. long collar to be welded on the center of the 54-in. blind flange. This retaining rod had to pass through the template flange. A stuffing box was welded into the center of the template flange to hold the rod, and prevent leakage of water around the rod.

An adjustable steel scaffold was used to support the tapping machine, thus preventing excessive strain on the 12-in. gate valves. It also provided a convenient working platform for operating the machine, changing bits and removing coupons.

To retain the 12-in. coupons, a special retaining pilot bit was used, which had two spring loaded steel balls near the tip of the pilot. These balls snapped out after passing through the blind flange, thereby holding the coupon on the pilot after completion of the cut.

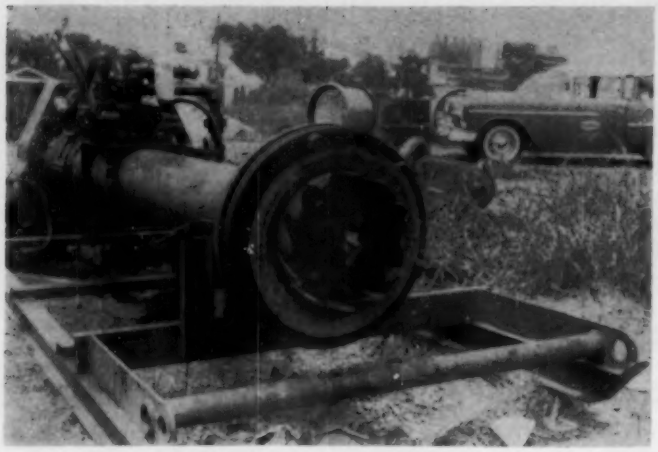
The tapping machine used had a boring bar travel of 72-in. Almost all of this travel was needed to get through the 12-in. and 48-in. valves to the 54-in. blind flange. The machine is hydraulically operated by a skid mounted hydraulic pump powered by a 19½-hp gasoline engine.

Supervision of this tapping job was by Tod Pazdral Pipeline Specialties and Phillips Chemical Company personnel.



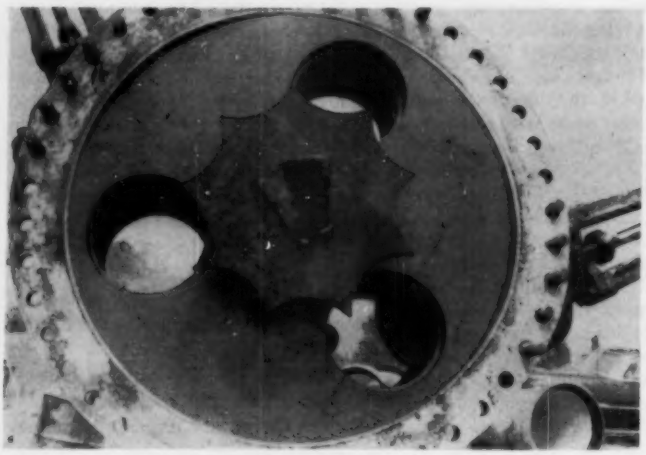
After valve was in place, the template flange with its three 12-in. gate valves (spaced at 120-deg intervals) is attached to the big gate valve. This view shows how the smaller valves are spaced.

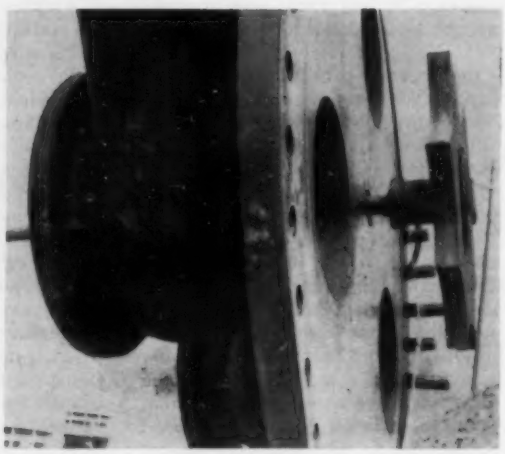
Nine little taps make ONE BIG TAP



Close up of taping machine with a 12-in. shell cutter.

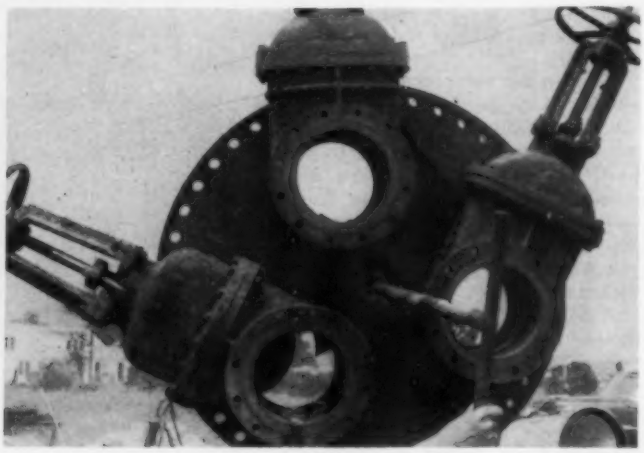
This is one of the coupons cut during the third position of the adapter flange. Note overlap of previous cuts.





Left, closeup of the center plug removed from the blind flange after final three cuts were made. Right, side view shows how retainer socket was welded to center line of blind flange so center plug could be removed after final cut.

Tapping machine is shown making cut with template flange in second position.



Closeup of the template flange. Note the 1½-in. polished steel retaining bar passes through the stuffing box welded to the template flange to prevent water leakage.

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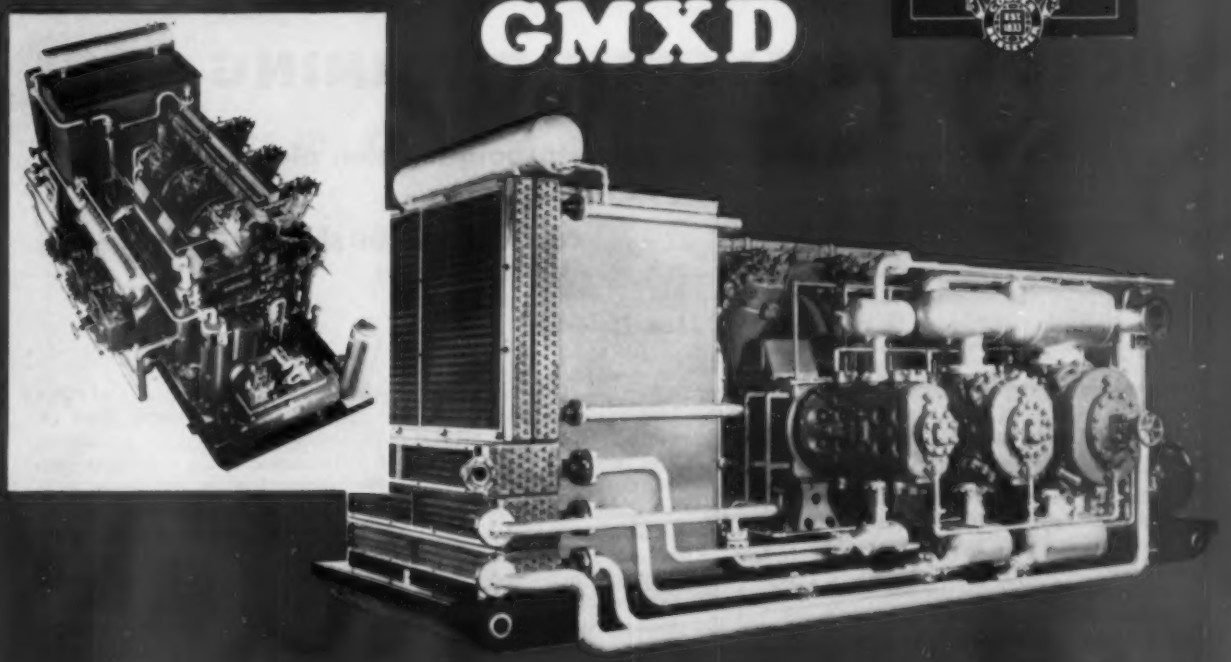
THE NEW, COMPLETELY PACKAGED

COOPER-BESSEMER GMXD

Another Example of Efficient Power at Lower Cost



Outstanding in simplified, economical installation . . .

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That's the word from the field on the new, pre-assembled GMXD compressor package. Patterned after the proven Cooper-Bessemer GMX, the packaged GMXD's combine exceptional compactness with the very latest advancements in gas engine and compressor design. They're available in 4, 6, 8 and 10 cylinder sizes, 250 to 870 horsepower . . . ready now to reduce costs to a new low in gas lift, booster, gathering, pressure maintenance and many processing services.

For fast service and delivery . . . in the heart of the oil and gas country . . . packaging of the Cooper-Bessemer GMDX is handled in Texas, Louisiana, Arkansas and New Mexico by Southwest Industries, Inc. of Houston 7, Texas. In these states, GMXD quotations are readily available from either Southwest Industries or any Cooper-Bessemer office.

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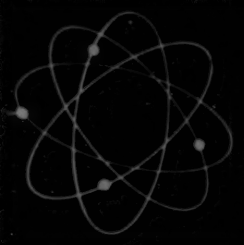


PIPE LINE COMMUNICATION & CONTROL

MICROWAVE SYSTEM PLANNING

A graphical approach to simplified point-to-point system planning

Part 1: Line-Of-Sight System Planning

Lee Elmore

About This Series and Its Microwave Planning Graphs

Microwave is an accepted natural companion to pipe line and other petroleum and natural gas industry operations today. Since microwave is apparently here to stay, it behooves all good pipeliners to develop at least a speaking acquaintance with this vehicle for communication and control.

The widespread use of microwave in the petroleum industry has created a need for some "common denominator" thinking. By this, we mean reducing numbers, equipment, and performance data to their fundamental or basic terms. Such basic information can then be charted to show exactly what can and cannot be done with microwave — for all frequency bands, equipment designs, and system philosophies.

Throughout 1956 THE PETROLEUM ENGINEER will carry a series of Microwave Planning Graphs. For the uninitiated, these graphs and accompanying explanatory text will provide a summary course in microwave by graphically displaying the basic requirements and results obtainable.

For those who live close to microwave in the field, these graphs will provide a handy reference for fast and accurate answers — without calculating logarithms or the danger of slipping a decimal place.

MICROWAVE SYSTEM PLANNING consists of matching equipment and paths to provide point-to-point communication and control functions of a specified quality and reliability.

This planning procedure has been refined to the point where a system can be laid out with only graphs and maps. When verified by field survey and sanctioned by engineering judgment, a graphically planned system can be engineered and installed with assurance that it will operate within a few db of predicted performance.

The delivery of a custom-installed microwave system, operating to full realization of planned and specified goals, involves a comprehensive engineering, manufacturing, and construction effort. Extensive engineering is required to design the system, lay out the installations, and tailor the terminations to provide the desired communications and control functions.

This concerted effort is largely the burden — and reason for being — of the microwave suppliers.

The major responsibility of the microwave purchaser is to plan well, work closely with the supplier in achieving the desired goal, and operate the completed system so as to maintain the desired quality and continuity of communication. It is a credit to the microwave users and suppliers who plan, engineer and deliver completed systems that the end result can be made to closely approach the planner's goals.

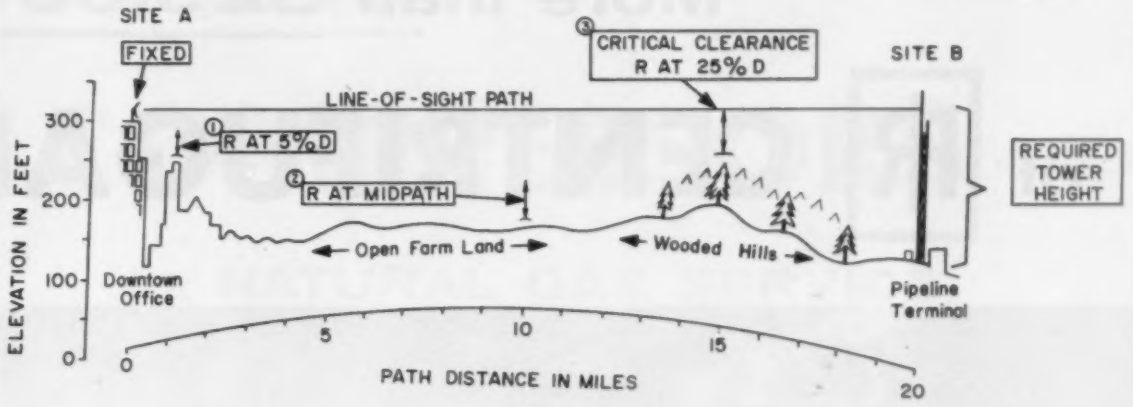
The past seven years of commercial microwave experience on the part of pipe lines, common carriers, and other users have provided ample data on which to base firm plans and guarantees of performance. These years have seen many innovations in microwave techniques and equipment design, but the basic physical concepts of line-of-sight transmission remain unchanged and well-proven. System plans still revolve around the fixed db and the variable — but statistically predictable — propagation phenomena.

The installation and operation of many pipe line microwave systems has also provided valuable information concerning both initial cost and maintenance expense of this communication medium for comparison with wire line facilities or leased circuits. Since dollars are more important and tangible to management than are db's, this economic aspect of microwave system planning will receive full attention in this series.

Path Considerations

Planning a microwave system for reliable point-to-point communications requires that the propagation path, as well as the microwave and multiplex equipment, be considered an integral part of the microwave system.

Selection of the microwave path should precede the selection of the equipment since the path will greatly affect the equipment requirements, system cost, and performance specifications. Since the microwave path and equipment are closely inter-related, however, the path should be selected



SAMPLE USE OF FRESNEL CLEARANCE GRAPH

Problem:

A microwave link is desired from a downtown building to a pipe line terminal 20 miles distant. The path profile is shown above, with proper earth curvature as discussed under PROFILE CHARTS on page D-58.

Find:

Tower height required at pipe line terminal to provide line-of-sight path with full first Fresnel zone clearance over all obstacles at 6700 mc.

Solution:

A. Use Fresnel zone graph to determine required clearance at midpath and at all prominent elevations. Locate percent distance (% D) for each obstacle for 20 mile path, and read first Fresnel zone radius (R) from 6700 mc scale.

1. **Nearby building: % D from nearest terminal = 1 mile/20 miles or 5%. R = 27 ft.**
2. **Midpath: % D = 50%. R = 61 ft.**
3. **Wooded Hill: % D from nearest terminal = 5 miles/20 miles or 25%. R = 54 ft.**

B. Plot required clearance over each obstruction as shown on sample profile chart. (Note allowance of extra 10 ft for future growth of trees, and safety margin of 10 ft at all points.)

C. Use straightedge to simulate line-of-sight path. Pivot edge about fixed antenna site at A, and extend line through highest required clearance point (3) to intersect tower at B. Vertical height from ground elevation to intersection is required tower height of 200 ft.

with the equipment capabilities in mind.

For example, the path length directly affects the following: Number of relay stations required; tower heights; voice channel signal-to-noise ratio; and available fade margin.

Conversely, the path length is limited not only by propagation factors but also by the following equipment factors: Available gain from transmitter-receiver; parabolic antenna size; ultimate channel capacity; specified S/N ratio and fade margin, and practical tower heights.

Path length is also greatly affected by the terrain and by the availability of practical sites. By designing the path with full consideration to both equipment capabilities and propagation characteristics, a microwave system can be engineered to provide maximum reliability and performance at a minimum cost.

There are many equipment alternatives and propagation path variables involved in planning a custom communication system. The equipment alternatives are design assets, since they permit the planner to select his parameters such as frequency band, antenna system, type of multiplex, etc., for the desired operation and for an economically justified but limited price. The propagation variables are design limitations in that they impose stringent demands for wide fade margins. This imposed reserve of db's, however, provides a large safety factor against equipment deterioration as well as propagation fades.

To aid in microwave system planning, the many variations in equipment choice and the propagation path variables have all been reduced to graphical form. The dozen graphs and accompanying explanatory text of this series condense microwave system engineering into the essential elements for convenient usage.

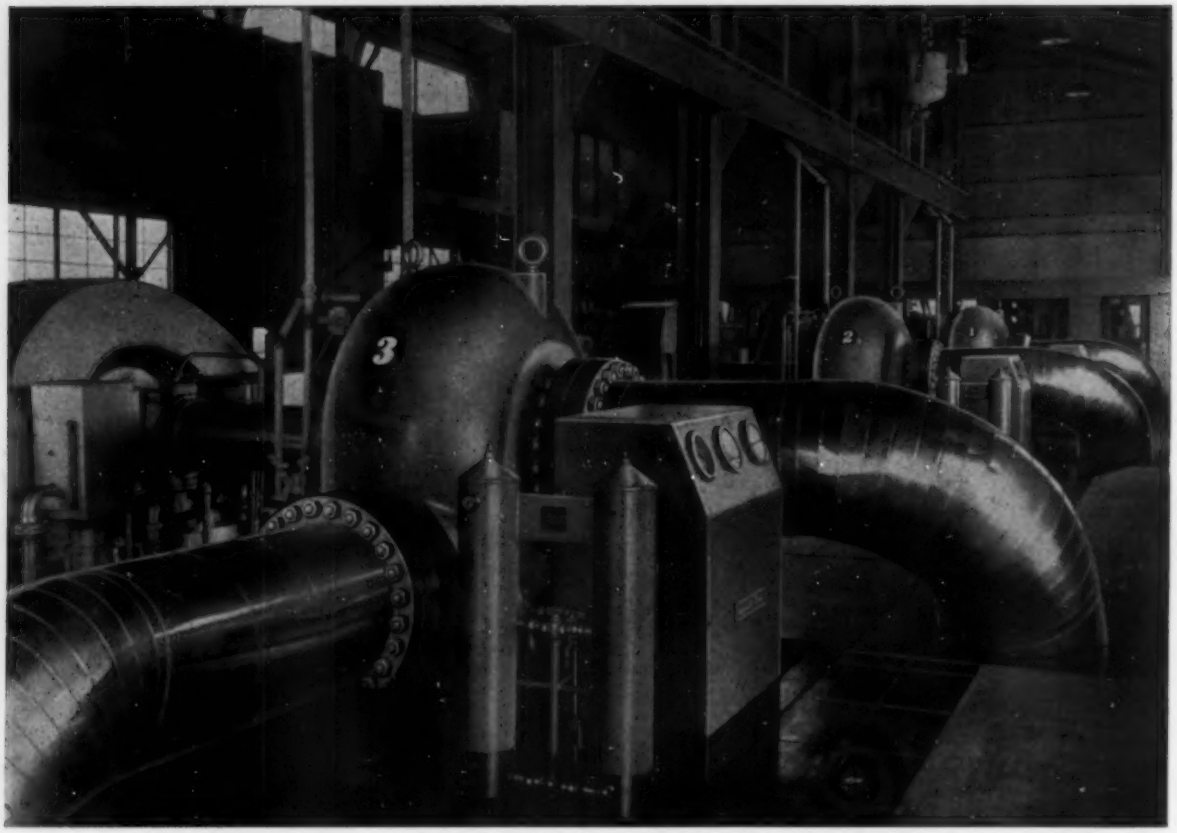
The charts have been developed for application in the petroleum radio frequency bands employed for operational fixed microwave—960 mc, 2000 mc 2600 mc and 6700 mc. The charts have been used during the past two years for planning a number of installed microwave systems, and their value and accuracy has been well demonstrated.

Microwave Path Calculation

The propagation of microwave energy through free space is readily calculated by converting transmitter power output, free space loss, antenna gains, and receiver threshold sensitivity into db for simple addition to determine received signal strength. This received signal, measured in terms of RF carrier-to-noise ratio, can be graphically depicted as a function of path length for various equipment types, frequency bands and antenna sizes.

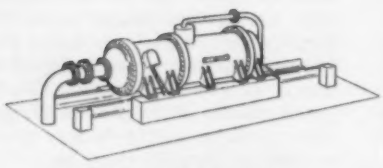
More than 325,000

of I-R CENTRIFUGAL



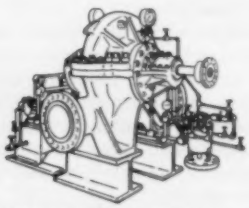
Three of 8 Ingersoll-Rand centrifugal compressors installed on a large natural gas pipe-line. Each unit is driven by a 5000 hp gas turbine.

I-R *"FIRSTS"* in Centrifugal Gas Compressor History



FIRST CENTRIFUGAL PIPE-LINE COMPRESSOR

Built by Ingersoll-Rand in 1931, this centrifugal pipe-line booster consists of a six-stage compressor driven by a 3550 rpm, 3000 hp motor, all encased in a pressure vessel.



FIRST COMMERCIAL APPLICATION

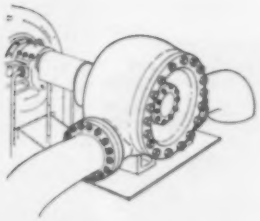
of centrifugal pipe-line compressors was made in 1947. A total of 78 electric-motor-driven, single-stage I-R centrifugals were installed, to handle approximately 250 mmcfd.

horsepower

COMPRESSORS

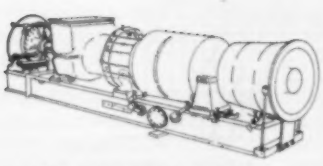
for NATURAL GAS SERVICE

This experience means
MAXIMUM DEPENDABILITY
in modern pipe-line service



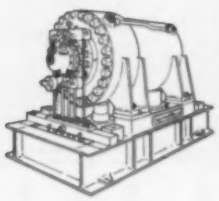
FROM the very first pipe-line installation, Ingersoll-Rand has pioneered in the development of centrifugal gas compressors for higher and higher capacities and pressures. And every step of the way, dependability of performance has been a prime consideration in every detail of design and construction. This is why more I-R Centrifugal Compressors have been sold for natural gas service than any other make . . . a total exceeding 325,000 hp for this service alone.

Backed by such long and successful experience, the modern I-R centrifugal gas compressor is your best assurance of trouble-free performance and long-range economy in gas transmission service.



FIRST GAS-TURBINE-DRIVEN UNIT

Installed in 1949, this Ingersoll-Rand centrifugal compressor, powered by an 1850 hp simple cycle combustion gas turbine, was the first gas-turbine-driven centrifugal compressor developed and applied to pipe-line service, and was designed for a flow of 192 mmcfd at a ratio of 1.18.



FIRST 2000 PSI CENTRIFUGAL GAS COMPRESSOR

This Ingersoll-Rand 5000 hp double-case centrifugal compressor was the first unit ever built for handling natural gas at a discharge pressure of 2000 psi.

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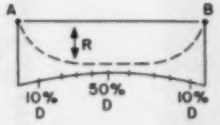
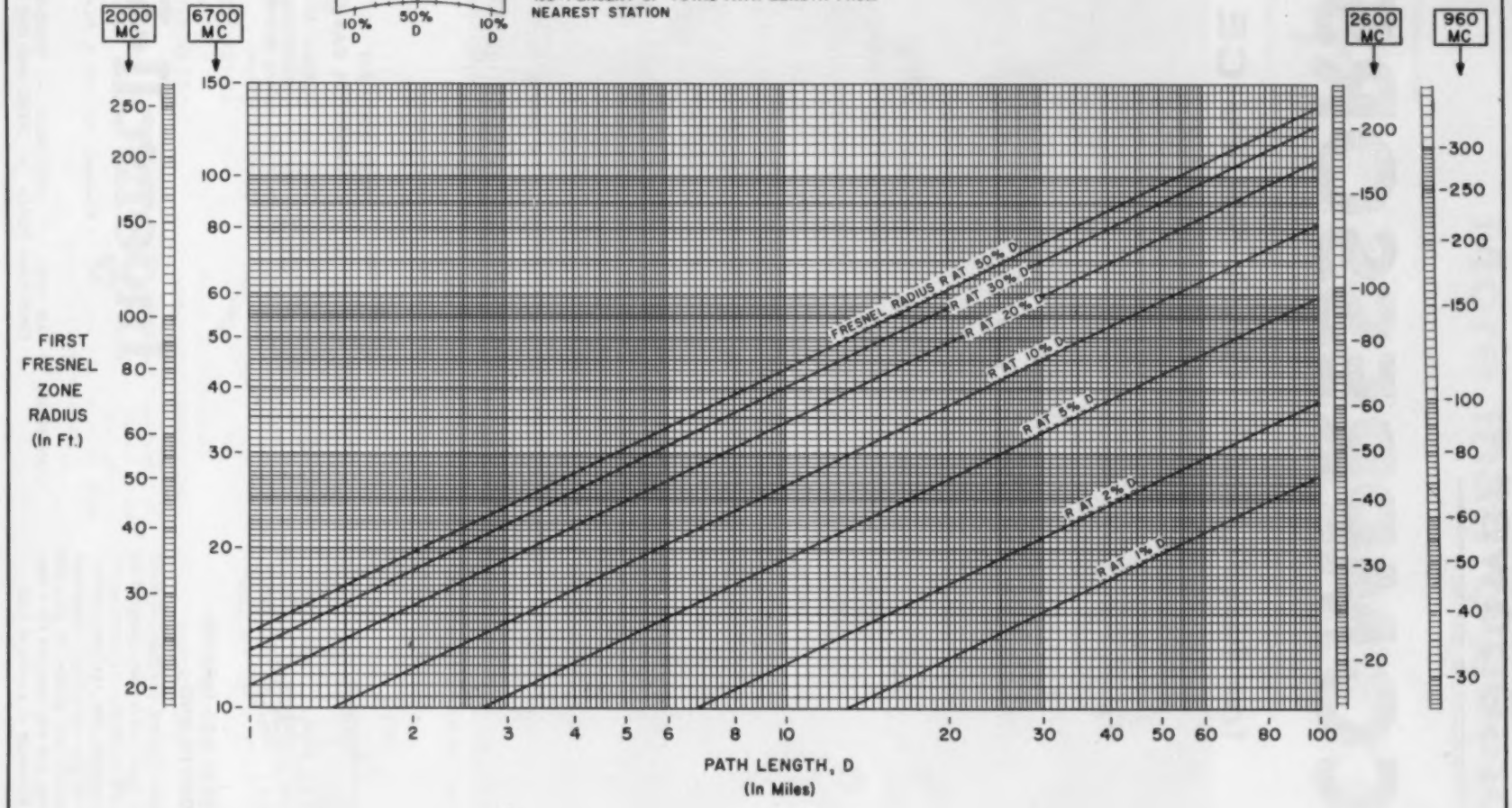
FIRST FRESNEL ZONE RADIUS, R



AB = LINE-OF-SIGHT PATH BETWEEN TWO STATIONS
PATH LENGTH = D MILES.
%D = PERCENT OF TOTAL PATH LENGTH FROM NEAREST STATION



The actual transmission of a microwave signal varies about the free-space calculated value because of refraction in the atmosphere (bending or ducting), reflection from the terrain surface (multipath transmission) and diffusion due to obstacles in the path. In addition, atmospheric losses occur due to a slight absorption of microwave energy by moisture and dust content of the air and a larger absorption loss by heavy rain or snow. Ample data have been accumulated to chart the effect of these propagation path variables and to correlate fade margin with per cent propagation reliability for typical paths.

Microwave path data acquired over the past seven years of commercial operation have verified the technique of calculating paths, so that the actual path under no-fade conditions will duplicate the calculated nominal path attenuation. Experience has also shown that the path attenuation will vary with propagation conditions between a maximum of 6 db above nominal to over 30 db below nominal, these two extremes existing a small percentage of time. Path attenuation will be within ±5 db of the nominal value more than 99 per cent of the time for all except problem paths.

A straightforward method of designing propagation paths is to plan the path on the basis of free space transmission, then make allowance for the propagation variables by proper fade margin allowance.

Generally, this means

(1) selecting a path for line-of-sight transmission plus clearance based on first Fresnel zone radius;

(2) determining free space transmission values;

(3) consideration of the normal and predictable extremes of propagation due to bending, terrain reflections, etc.;

(4) compensation for these effects by incorporation of adequate fade margin to provide the desired degree of reliability; and

(5) if necessary, readjustment of tower heights, selection of an alternate path, or provision of diversity reception.

In addition to the above propagation factors, microwave path planning must include consideration of the practical matters of geography, available sites, CAA and FCC regulations, and the relative cost of access roads, power pulling, and tower heights. These earthy factors will be covered in more detail later in this series.

Fresnel Zone Clearance

In order to obtain substantially free-space transmission over a microwave link, it is necessary to provide a clear zone between microwave antennas (or reflectors) at adjacent stations. This clear zone is a line-of-sight path plus a required clearance between the center line of the path and the terrain profile along the route between the two stations.

The required clearance is based on the first Fresnel zone radius. The first Fresnel zone is a cigar-shaped zone extending between the two antennas. The radius of this zone at any point over the path is a function of the path length, distance from the point to the nearest terminal, and the wavelength, or frequency, of the microwave signal being transmitted. The first Fresnel zone radius, R, at the four microwave bands employed for Petroleum Radio Service is plotted in the accompanying graph for any path length and for various points over the path.

Maximum transmission level over a microwave path occurs when the clearance at any point equals the first Fresnel Zone radius, R.

Conversely, the loss over a path is greatest when the clearance equals the *second* Fresnel zone radius (or any other even-numbered Fresnel zone). These Fresnel zones are physically defined and illustrated on D-58.

In the microwave link represented

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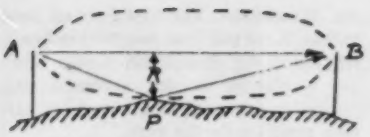


above, the signal received at Terminal B is the sum of a direct wave (path AB) and a reflected wave component (path APB). The reflected wave undergoes a 180-deg phase reversal at point P. Consequently, if the path APB is one half wave length longer than AB, the direct and reflected wave components arrive exactly in phase and add directly. The first Fresnel zone is bounded by all points which provide a path length ½-wavelength longer than the direct path. The first Fresnel zone radius, R, is shown dotted in the above figure.

The *second* Fresnel zone is bounded by all points which provide a path one full wavelength longer than the direct path. The 180-deg reversal which occurs in reflection causes the direct and reflected wave components to arrive in phase opposition and results in some signal cancellation, the degree of cancellation being proportional to the reflection coefficient to the terrain. This second Fresnel zone is concentric around the first Fresnel zone.

The third Fresnel zone is bounded by points which provide paths 3/2 wavelength longer than the direct path. The signal reinforcement is the same as for the first Fresnel zone.

Similarly, the fourth Fresnel zone and all other even-numbered Fresnel zones produce phase cancellation as in the second Fresnel zone case. (This fourth Fresnel zone radius = 2 R.)

As bending occurs over a microwave path designed for first Fresnal zone clearance, the **actual** clearance will vary from a fraction of R to several times R. Consequently the transmission level will vary as the direct and reflected wave components arrive in various phase relations. The amount of this variation from free space transmission depends upon the variation in clearance and upon the type of terrain. The effects will be further explained and graphically summarized later in this series.

Profile Charts

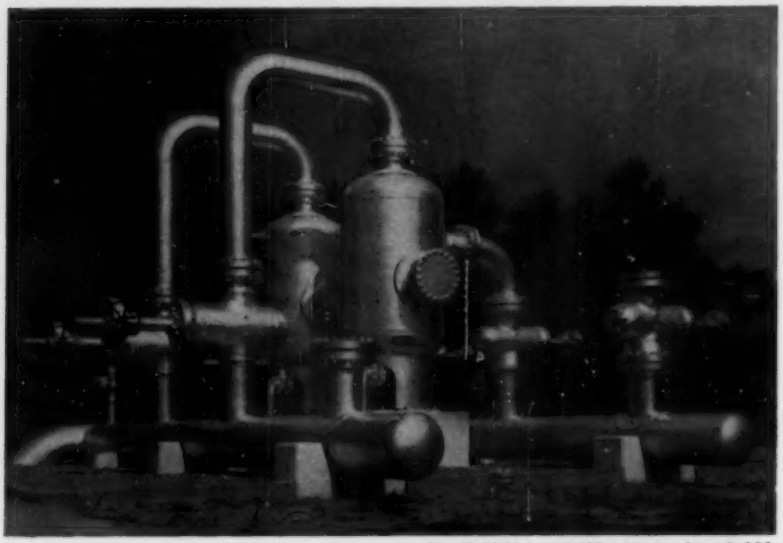
The earth's curvature, terrain elevations and the existence of obstructions such as buildings or trees in the path must be considered in planning a path to provide the required line-of-sight transmission with proper terrain clearance. Profile charts are employed for checking whether or not such a path and clearance exist over a proposed route, and also for determining exact tower heights required to provide a specified clearance. Profile charts show terrain elevation versus distance, with the horizontal lines curved to correspond to the earth's curvature.

Profile charts employed to plot 6700 mc microwave paths are based on true curvature. A slight downward bending of microwave beams normally occurs due to dielectric gradient of the atmosphere. At lower frequencies, profile charts are usually plotted with 4/3 earth radius to allow for this slight "flattening" of earth. Earth size effectively varies from "flat" to 2/3 radius. Part II of this series on Microwave System Planning will include sample profile charts and curves showing the effective "bulging" and "flattening" of the earth as bending of the microwave occurs under various propagation conditions.

Microwave Field Surveys

In order to assure reliable communication between two points, a microwave field survey is required to select microwave routes and/or confirm propagation paths and tower heights.

In the case of a two-terminal system involving a short propagation path between two prominent sites (e.g., downtown office building to nearby mountain peak), a visual check of the path and inspection of the two sites may



Manifolded to provide a capacity of 200 MM SCFD at 650 psig with a pressure drop of 1.5", these Aerotec units remove both dust and liquids from the gas.

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On this 845 mile, 30" feeder line from Louisiana to West Virginia, five compressor stations present wide variations in contamination of gas being transported.

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suffice to check the existence of a line-of-sight transmission path with adequate clearance.

In long multi-hop microwave systems, which involve a number of relay stations, a microwave survey is generally required to investigate alternate routes and select relay station sites, determine tower heights for proper clearance over the path, and to design the propagation path for the maximum reliability.

In such a comprehensive survey, a detailed map survey must be first conducted and profile charts plotted of the alternate routes. A field survey crew is then sent to investigate the possible sites, to make accurate elevation measurements of the critical points in the path, and to check for possible atmospheric problems, reflections or obstacles.

Field surveys may utilize aerial techniques, a ground survey or a combination of the two. The technique of radar profiling of microwave paths was covered in Capt. W. C. Eddy's article in the May, 1955 issue of *The Petroleum Engineer*. The elements of ground surveying will be presented later in this series.

Channeling

The end product of a microwave system is not a radio signal but a number of 2 or 4-wire circuits that may be employed for a variety of functions — voice, supervisory control, telemetering, teletype, mobile radio tie-in, facsimile, or telephone terminations of various types. The multiplex equipment employed to load many channels over a single radio beam must be considered in planning the point-to-point circuits. The effect of multi-channel loading can be depicted graphically to correlate voice circuit quality with the radio system parameters and fade margins.

A practical approach to planning point-to-point circuits, utilizing graphs and channeling diagrams, will be presented later in this series. The functional usage and loading effects of narrow band tone channels will also be covered.

Sample Problems

A typical problem in microwave system planning will be solved to illustrate the usage of each graph throughout this series. The accompanying sample profile and problem outlines the procedure for obtaining first Fresnel zone clearance over a path. Future articles will discuss the use of 0.6 R and various other practical considerations of propagation paths, site selection, equipment selection and system planning. The entire series should summarize and illustrate the graphical method of planning your point-to-point communication and control facilities. ★ ★

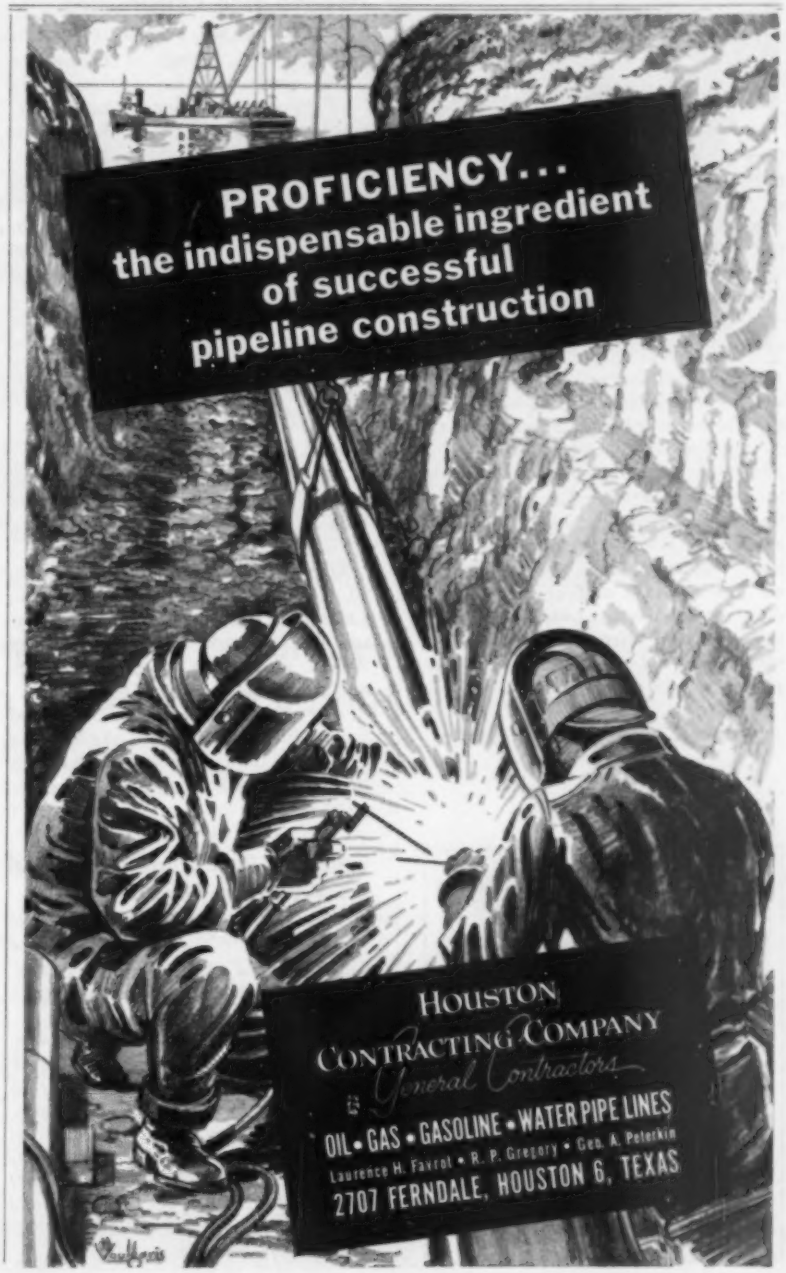
Arc Welding Foundation Offers $20,000 for Ideas

The James F. Lincoln Arc Welding Foundation of Cleveland, Ohio, is offering $20,000 in cash awards for ideas or suggestions that will accelerate progress in arc welding. Residents of the United States or its possessions are invited to submit ideas to the Foundation on any aspect of arc welding that can be used to advance welding design, welding engineering or the general application of the arc welding process. No restrictions are placed on either the nature or the extent of ideas that may be submitted for award. The $20,000 will be distributed in 20 awards with a top award of $5000, others $4000, $3000, $2000 and $1000 and additional smaller awards.

Ideas must be submitted by July 30, 1956.

Dr. E. E. Dreese, chairman of the foundation describes the offer as an exploratory program to discover ways in which arc welding can continue to progress. The foundation, Dreese states, seeks to stimulate continuous progress in all of these fields.

Complete information and rules are available from The James F. Lincoln Arc Welding Foundation, Cleveland 17, Ohio.



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Pipe Line Projects

Union Oil Gets Permit For Arizona Products Line

Union Oil Company has been granted permission to install a products pipe line in Arizona. The city of Phoenix and Maricopa County have given the company a franchise to construct the pipe line from the Southern Pacific terminal to Union's bulk plant in Phoenix.

Holland Line Construction Opened to U. S. Contractors

Bidding was opened in January to U. S. contractors for approximately 34.8 miles of 8-in. line in the Netherlands, the Bureau of Foreign Commerce announced.

The project involved supplying, coating and laying the pipe, including construction of valve pits, cathodic protection and 0.6 mile of river crossing, and supplying of nine valves. Estimated cost is about $760,000.

Competitive bidding followed the procedure of the North Atlantic Treaty Organization.

Interstate Oil Completes Two Louisiana Trunks

Two trunk lines have been completed in Louisiana for Interstate Oil Pipe Line Company, of Shreveport, Louisiana.

One of the projects was a 12 mile, 12-in. extension of its Grand Isle-Little Lake trunk line into the Lake Washington field. Construction involved laying 8 miles of 4 and 8-in. gathering lines and five elevated pump stations.

A 9-mile trunk has been completed linking Interstate's Delhi-Lake St. John trunk with the Locust Ridge field. This project included installation of a gathering line.

Cathodic Protection Completed on Wyoming-Missouri Line

Cathodic protection program has been completed for the Service Pipe Line Company's 625-mile Ft. Laramie, Wyoming, to Freeman, Missouri, crude oil pipe line.

Service completed the 20-, 22-, 24-in. line late in 1954.

Pipe Line Anode Corporation, of Tulsa, made the protective installations. They utilized the rectifier-type of unit combined with both vertical and horizontal ground beds. Graphite rods were used in both types of ground bed installations. A total of 15 rectifier units protect the line.

Sinclair Begins "Big Inch" Crude Line in Texas

Sinclair Pipe Line Company has awarded a contract for the construction of a segment of the company's new "Big Inch" crude oil carrier in the state of Texas.

River Construction Corporation of Fort Worth, Texas, will lay 150 miles of 18-in. pipe from Jacksboro to Teague, Texas. Construction will start about February 1, and is expected to be completed by May 1, 1956.

The line will provide necessary increased capacity to move North Texas oil to Teague, and from there to the Houston refinery area.

Tennessee Gas Plans 200-mile Butane Line

Tennessee Gas Transmission Company is planning expansion of its butane operations west of Corpus Christi, Texas. Proposed, although not officially announced by the company, is construction of a 200-mile pipe line, a $2,000,000 LPG separator plant and underground storage tanks, as well as barge, truck and rail loading facilities on the nearby Houston ship channel. The line will take LP gases produced at the Banquete natural gasoline plant west of Corpus Christi.

Plans for the line were revealed through negotiations with the Houston Navigation District Port Commission for land along the ship channel needed for the separation plant.

The line will move butane, propane and natural gasoline in a mixed stream to the liquid gases plant, where the products would be separated. From this point, the products would either be piped to the loading docks or to underground storage in the salt domes nearby. Most of the produced butane will be put into this storage until completion of the expanding Petro-Tex Chemical Corporation plant at Houston. This plant, which will use the butane in its production of butadiene, is jointly owned by Tennessee Gas and Food Machinery & Chemical Corporation.

El Paso Natural Plans New West Texas Project

El Paso Natural Gas Company has announced expansion plans calling for $20,000,000 of construction this year in the El Paso, Texas area. Plans call for the construction of two gas treating plants and a pipe line. Details have not been announced.

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These and other 308 features mean smooth, low-cost ditching . . . more ditch per dollar with the greatest return on your capital investment. They also mean longer life, less maintenance and less downtime. These advantages explain why pipeliners expect and get *more* for their money in Gar Wood-Buckeye ditchers. See for yourself. Ask your dealer to show you the model 308. Ask him, too, about the full range of factory options that can tailor it to your particular application and soil conditions.

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Contracts Let On First Military Pipe Line

Nearly all of the federal contracts have been let on the 176-mile, 6-in. military pipe line which will tie in four Arizona and California Air Force bases to Southern Pacific Pipe Line's California-Texas petroleum products line. This will be the first major military pipe line to be constructed in the U. S.

The Air Force line, a complete system in itself, will service March Air Force Base, near Riverside, California; Davis Monthan AFB, Tucson, Arizona; Luke, AFB, near Phoenix, and Williams AFB, southeast of Phoenix.

Engineers Limited Pipeline Company, Los Angeles, has been awarded contract on 86 miles of line from the Davis Monthan base to a point near Magma, Arizona.

Contract has been let to Hood Construction Company, Los Angeles, on 58 miles of line between Magna to the Williams base and on to the pumping station at Phoenix, and 18 miles of line from the pumping station to Luke base.

Out for bids is 14 miles of lines to be laid from the Colton, California, pumping station to the March base. Phoenix pumping station contract is still open.

Installations contract at Norwalk, California, has been let to J. H. Pomeroy & Company, Los Angeles. Jet fuel and aviation gasoline will be received into the line at Norwalk.

J. A. McNeil Company, Inc., Alhambra, California, holds the contract for work on the pumping station at Colton and the metering installation at the March base.

Metering installations at Luke, Williams and Davis-Monthan Air Force base has been given to M. M. Sundt Construction Company.

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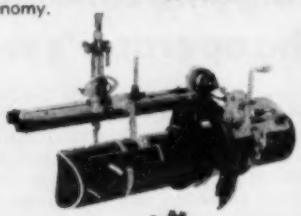

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Mid-Continent Buys Natural Gasoline Line

Mid-Continent Pipe Line Company has recently completed reconditioning and laying of additional line on a 26-mile natural gasoline line in Stephens and Carter counties, Oklahoma.

The 4-in. line, feeding water-white gasoline to the D-X Sunray refinery at Duncan, has a 2500 bbl daily capacity and pumps natural gasoline from the Signal Fox, Sokla, Skelly Velma and Sohio gasoline plants.

The line was previously owned by the Sunray Oil Corporation and Kerr-McGee Industries, Inc. Mid-Continent Pipe Line acquired the Sunray interest when Sunray and Mid-Continent Petroleum Corporation merged last year, and then took over completely through the purchase of the Kerr-McGee interest. Mid-Continent Pipe Line is a subsidiary of D-X Sunray Oil Company which is in turn a subsidiary of Sunray Mid-Continent Oil Company.

Two miles of additional line have been laid and certain reconditioning and realignments have been made to facilitate direct pumping of gasoline from the four plants to the D-X Sunray refinery.

Service Adds Pump Station On Wyoming to Missouri Line

A new crude oil pump station will be constructed near Sterling, Colorado, by Service Pipe Line Company to increase capacity in the company movement of Wyoming crude oil to midwestern refineries.

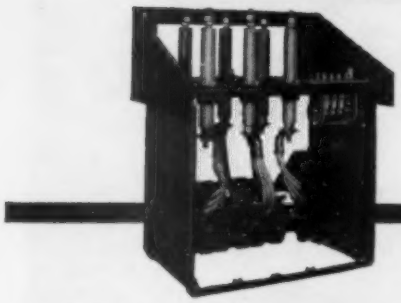
The new manually operated station will increase pumping ability along the 625-mile line between Ft. Laramie, Wyoming, and Freeman, Missouri.

Plans have been made to install one 1000-hp and two 1500-hp electrical-centrifugal pumping units at the station. The two new pumping units will replace the existing injection unit now being used.

Construction work on the new station will be done by the company's Wyoming division crews. R. R. Strand, Casper, is manager of the Wyoming division and Opal Blair, Sterling, is the district superintendent.

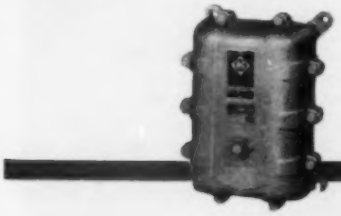
These Safety Features

meet operating demands of combustible atmospheres



Oil-immersed main contactor for safe operation

The complete contactor, including magnet and auxiliary switches, operates under oil to prevent sparks from igniting atmosphere and to protect mechanism from corrosion.



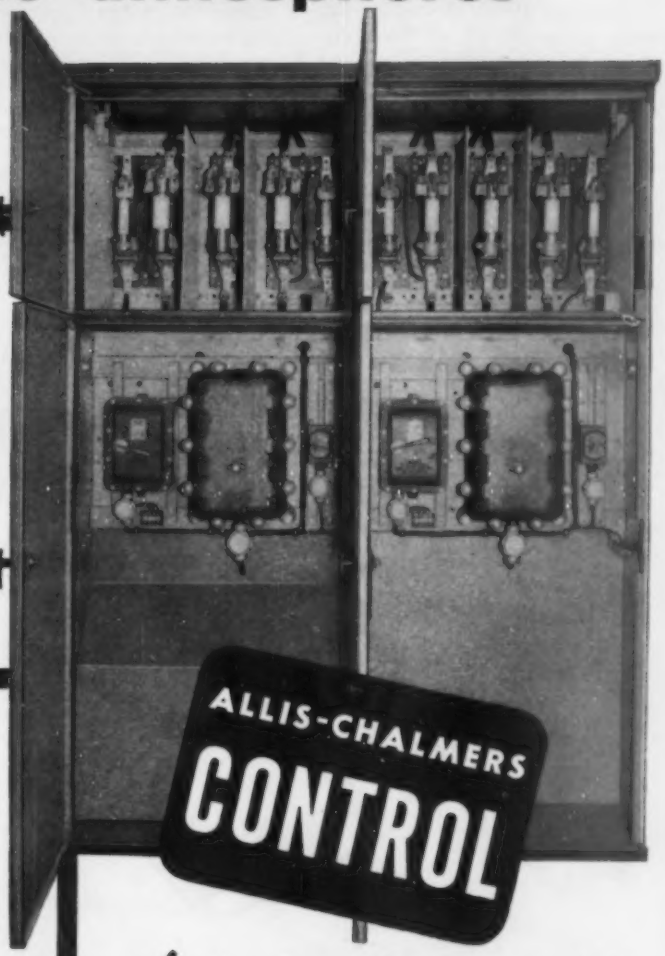
Relays and switching devices in explosion-proof cases

Further protection against the possibility of explosion is provided by NEMA VII enclosure which houses all overload, undervoltage, timing and auxiliary control relays as well as other low voltage switching devices.

Interlocked fuse compartment door

The fuse disconnect door is interlocked. The line contactor must be opened before access to the fuse is possible.

Other features *Steel barriers* in rear compartment prevent accidental contact with high voltage parts. Enclosure is finished with corrosive-resistant paint. Indoor or outdoor control equipment may be provided.



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Pipe Line News

Corrosion Discussion Set For Annual NACE Meeting

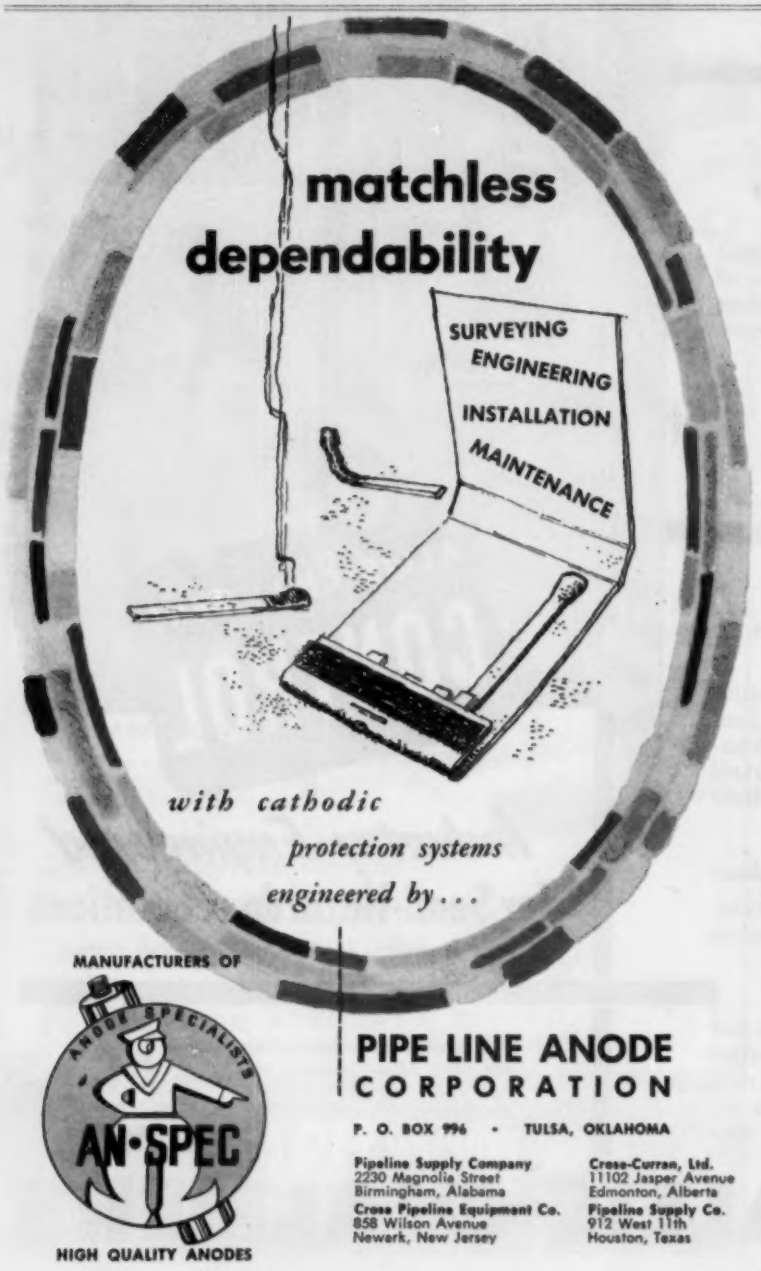
Nine discussion groups on pipe line corrosion will be one of the principal features of the annual meeting of the National Association of Corrosion Engineers. Group leaders will be experienced in such fields as gas, oil, coatings and cathodic protection. The NACE Twelfth Annual Conference and 1956 Corrosion Show will meet at the Statler Hotel, New York City, March 12-16.

Four technical papers will be presented in the Pipe Line General Symposium. Titles of the papers are, Performance Tests on Pipe Line Coatings, Cathodic Protection of Certain Semimarine Pipe Lines, Experiments Employing Diatomaceous Earth in Products Pipe Line Filtration, and An Outline of a Physical Theory of Underground Corrosion. Chairmen for the symposium are L. G. Sharpe, Napko Paint and Varnish Company, Houston, Texas, and R. C. Martin, Plantation Pipe Line Company, Atlanta, Georgia.

The Pipe Line and Underground Corrosion Roundtable will be an informal meeting devoted to discussions. Chairmen are L. B. Nelson, Shell Pipe Line Corporation, Houston, Texas, and O. W. Wade, Transcontinental Gas Pipe Line Corporation, Houston, Texas.

Other technical paper of interest to pipe line men will be given.

L. R. Sheppard, Shell Pipe Line Corporation, Houston and C. L. Woody, United Gas Corporation, Houston, are chairmen for the groups.



Westcoast Pipeline Reorganized Under Mills

Reorganization of the West Coast Pipeline Company was announced recently by John B. Mills of Dallas, new president.

John B. Mills

The company, organized to develop a twenty-four inch crude oil pipe line from West Texas to Los Angeles, is now owned by forty independent oil producers. Plans now call for increasing the line to thirty inches, Mills said, in keeping with West Coast crude oil demand.

An advisory committee of independent oil producers has been set up, Mills said, to carry to Washington the fight for recognition of the line's necessity to national defense. Advisory committee members are: John B. Mills, Dallas; Ray E. Hubbard, Dallas; Summerfield Roberts, Dallas; Neely G. Landrum, Dallas; Rr. Adm. Wm. W. Studdert, USNR, RE, Midland; J. A. Humphrey, Dallas; Sol Brachman, Fort Worth; H. E. Chiles, Jr., Midland; Burt E. Hull, Dallas; John W. Naylor, Fort Worth; Jack Woodward, Dallas, and C. G. Johnson, Dallas.

Montana-Dakota Utilities Buys Wyoming, Montana Lines

Montana-Dakota Utilities Company will acquire the pipe line facilities of Montana-Wyoming Gas Pipe Line Company located in Wyoming and Montana, which have been operated by Montana-Dakota under leasing arrangements.

FPC recently issued an order authorizing Montana-Dakota to issue 241,577 shares of common stock of Montana-Wyoming in exchange for all of the latter company's properties and assets, and to assume Montana-Wyoming's $4,874,000 first mortgage pipe line bonds.

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Interprovincial Awards 119-Mile Loop Contracts

Contracts for laying 119.4 miles of large-diameter loop, valued at $9,000,000, have been awarded by Interprovincial Pipe Line Company.

Majestic Contractors, Ltd., of Edmonton will lay 67.4 miles of 24-in. pipe and 2 miles of 26-in. pipe in Manitoba. The 24-in. loop will parallel the 16-in. loop between Carroll and Somerset. The line will start at the Somerset scraper trap and run west to the tie-in point, near Brandon, with the feeder line for the Anglo-Canadian Oils, Ltd., refinery. One river crossing on the line is involved in this project. The two miles of 26-in. pipe is the Canadian portion of a loop which will run east from Gretna pumping station through a corner of North Dakota and part of Minnesota.

Anderson Brothers, Houston, Texas, has been awarded the American contract.

The looping program is designed to increase crude throughput capacity of the system from 183,300 to 241,500 bbl per day between Cromer and Gretna, and an increase between Gretna to Clearbrook from 156,200 to 212,700 bbl per day. It will result in not only increased throughput, but provide capacity to handle the flow of light crude from southeastern Saskatchewan through the Westspur pipe line to Cromer pumping station, now under construction by Majestic Contractors.

OIPA Urges Stronger Common Carrier Laws

Oklahoma Independent Petroleum Association, meeting last month, heard recommendations by Roy Woods, president of the organization, suggesting that "the state corporation commission and the legislature adopt some effective common carrier legislation that will materialy reduce the number of wells serviced by trucking companies, as opposed to pipe lines."

There has been some concern by oil producers about charges being assessed truckers for the movement of crude from well to pipe line or refinery. It was suggested that there is no fixed tariffs or charges of conditions, although the truckers operate under a corporation commission permit. Under such a situation, the producer may be undecided as to whether the transporter is a hauler or a broker with a commitment on his oil, Woods asserted.

Transcontinental Votes 2-for-1 Stock Split

Stockholders of Transcontinental Gas Pipe Line Corporation approved a 2-for-1 split of the company's 3,530,000 outstanding shares of common stock. To provide sufficient stock to effect the split, the stockholders also approved an increase in the authorized common stock from 5,000,000 to 10,000,000 shares. Each holder of common stock is receiving a new certificate equal to the number of shares held on January 20, 1956.

Directors of the company also declared an initial quarterly dividend of 22½¢ a share applicable to the split stock, payable February 1 to holders of record January 20. This represents an increase to the equivalent of $1.80 a share annually on the old stock which had been receiving $1.40 annually since dividends were inaugurated.

Holders of over 3,000,000 shares, or 86 per cent of the outstanding shares of the company's common stock, were represented at the special meeting.

In announcing the action of the stockholders and directors, Tom P. Walker, president of the company stated that the additional facilities constructed in 1955, increasing the allocated capacity of the Transcontinental system from 565,000,000 cu ft to 705,000,000 cu ft per day, have enabled the company to maintain on a sustained basis the highest volumetric deliveries of gas to customers in its history.

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And not just our tests show this deeper penetration. See what happened when a major oil company ran their own tests. They set up duplicate targets, identical except that the tensile strength of the cement in one was 450 psi and 558 psi in the other. Tougher targets were for #7 Powder...but for all that, bullets driven into these targets by #7 Powder penetrated 8.30" to the point of the bullet as compared to 6.22" of penetration gained by bullets fired into the easier targets.

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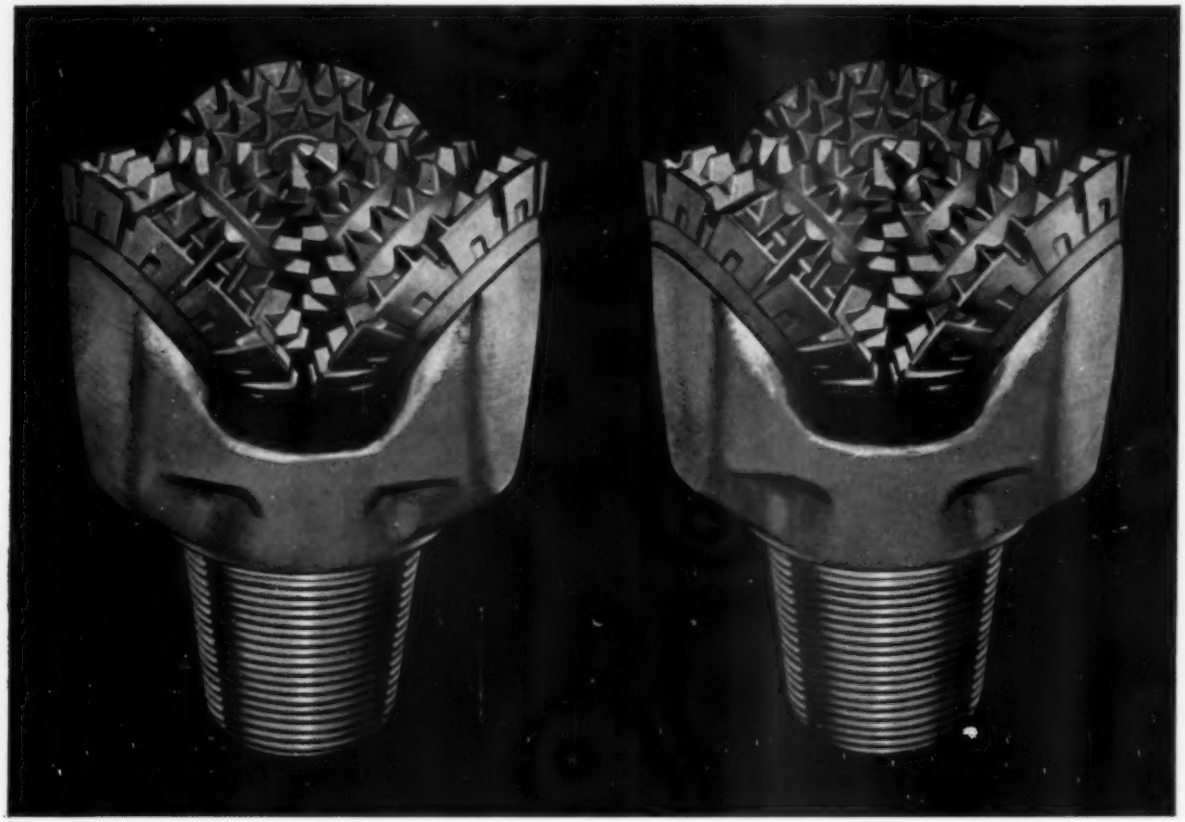
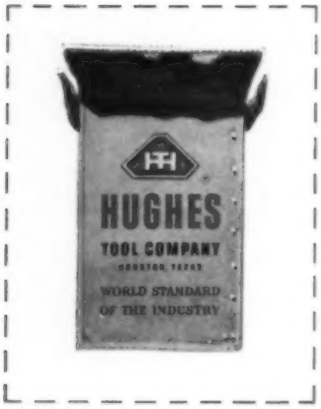


THEY LOOK ALIKE ... but



Because bits look alike is no certainty they will perform alike. Take the case of the two bits shown here.

There is a metallurgical improvement in the second bit that was not present in the first. This combined with design changes gives the bit greater stamina and assures *more hours on bottom ... making more hole!*

This is another example of the constant changes being made by HUGHES to enable operators to take full advantage of new drilling techniques.